The U.S. Global Energy and Water EXchanges (U.S. GEWEX)

Soil Moisture Workshop

April 16, 2021

U.S. Global Change Research Program

U.S. Global Change Research Program (USGCRP)

- An interagency program that coordinates global change research across the Federal government and uses research results and products to inform decisions relating to risk management in a changing climate.
- Delivers products mandated by Congress, such as the National Climate Assessment, Our Changing Planet, and topical reports
- 13 participating agencies

INTERAGENCY WORKING GROUPS		
Adaptation and Resilience	Carbon Cycle	Coasts
Human Health	Indicators	Integrated Water Cycle
International Activities	Modeling	Observations
Social Science	Sustained Assessment	

Integrated Water Cycle Group (IWCG)

Seeks to better understand the role water plays in a changing climate and how a changing climate affects water, as well as coordinate research to support water decision-making.

Water/Energy Cycle | Hydrology/Watershed | Resilience/Adaptation

U.S. GEWEX

Coordinates research based on *satellite and surface-based observations*, *global and regional process resolving models,* and the resulting *diagnostics and data* to enhance a **predictive understanding of the <u>water and (surface) energy cycles.</u>**

Current foci include:

- Precipitation Predictability
- Hydroclimate

Dr. Gary Geernaert
SGCR Principal for DOE

Opening Remarks

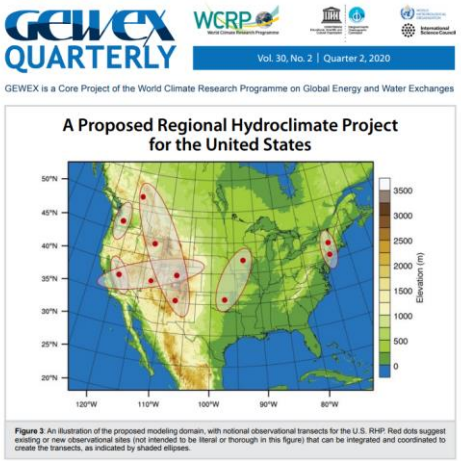
U.S. GEWEX Hydroclimate Workstream

Long Term Goal: Support Regional Hydroclimate (RHC) Studies

Build **a comprehensive network** that will enable regional hydroclimate studies/projects that **span observations and modeling**, requiring coordinated **sub-decadal to decadal** (5+ year) **efforts**, that would include a variety of short-, medium-, and long-term activities.

Short term activities (such as agency webinars, community workshops, white papers and targeted interagency collaborations) that build off **current science needs, field sites and networks, remote sensing observations, and modeling initiatives** would facilitate development of **larger, longer-term investments** in coordinating joint field plans and model plans, interagency field campaigns, coordinated data archival, and potentially coordinated and/or collaborative synchronous research solicitations.

Connects to International GEWEX RHP concept for the US/ Americas



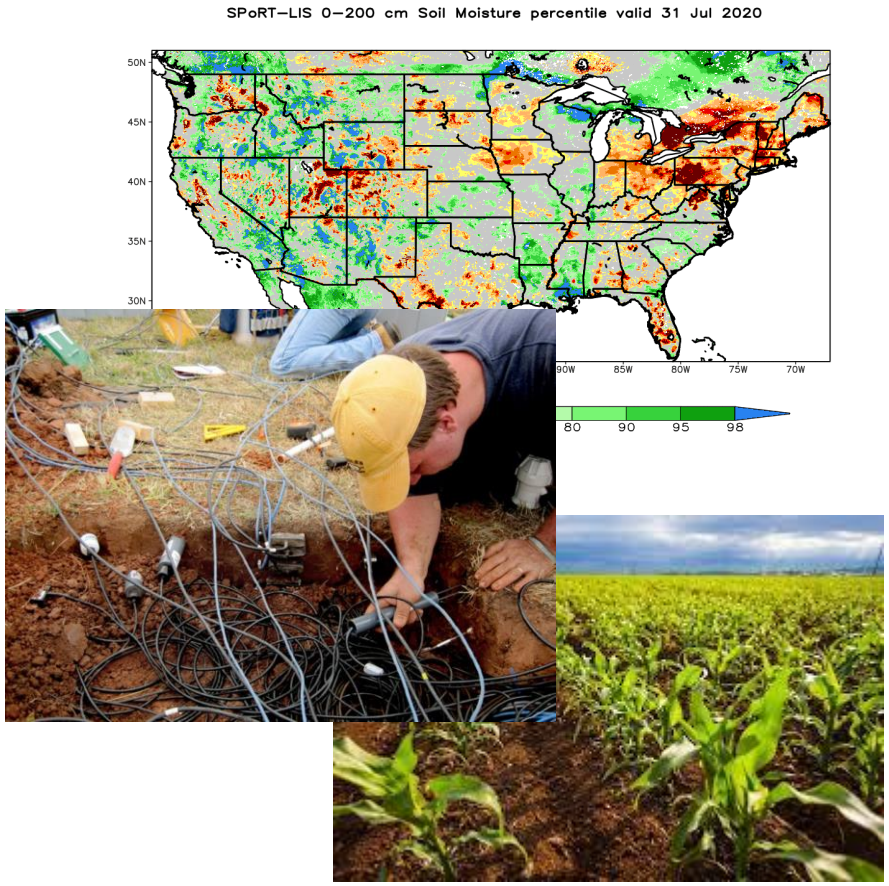
Follows the legacy of previous interagency continental scale efforts

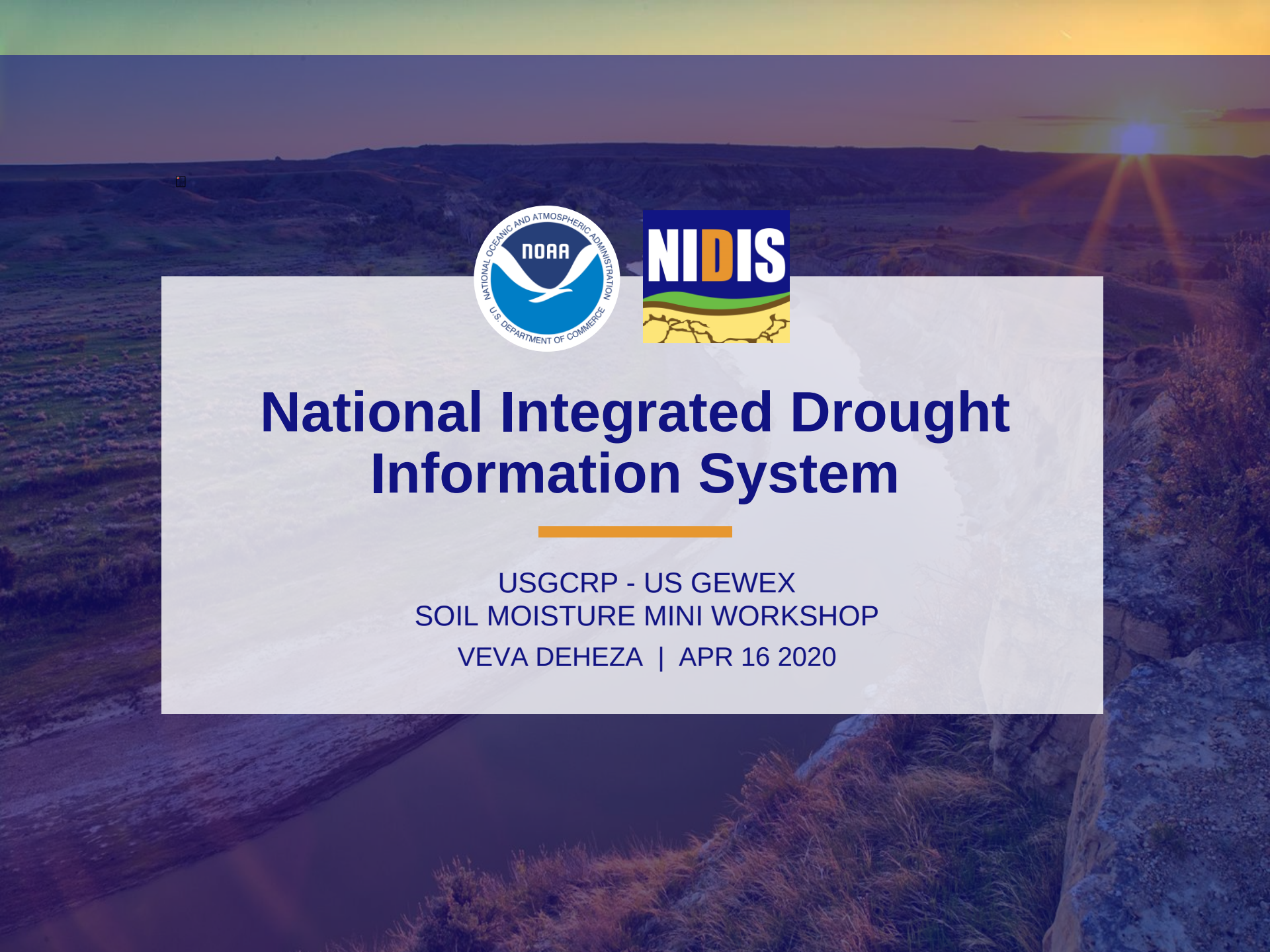
U.S. GEWEX Soil Moisture Focus

Historically, a major emphasis of GCIP/GAPP was on balancing the water budget.

Soil moisture is now well recognized for its role in the water and energy budgets as well as its influence on other terms.

- Multiple soil moisture in situ observations, satellite observations, and modeled products, and metrics/indices exist and are funded across agencies.
- Such collective assessments and data coverage of soil moisture conditions, made better through cooperation, can also be as a step to improved hydroclimate (and hydrometeorology) efforts, which will need to build and bridge our understanding of the water cycle in both top-down and bottom-up approaches
- Opportunities to align and contribute to other interagency interests/efforts – e.g. the R&D Strategic Framework for Earth system Predictability (Fast Track Action Committee under OSTP)
- Today is just a start…





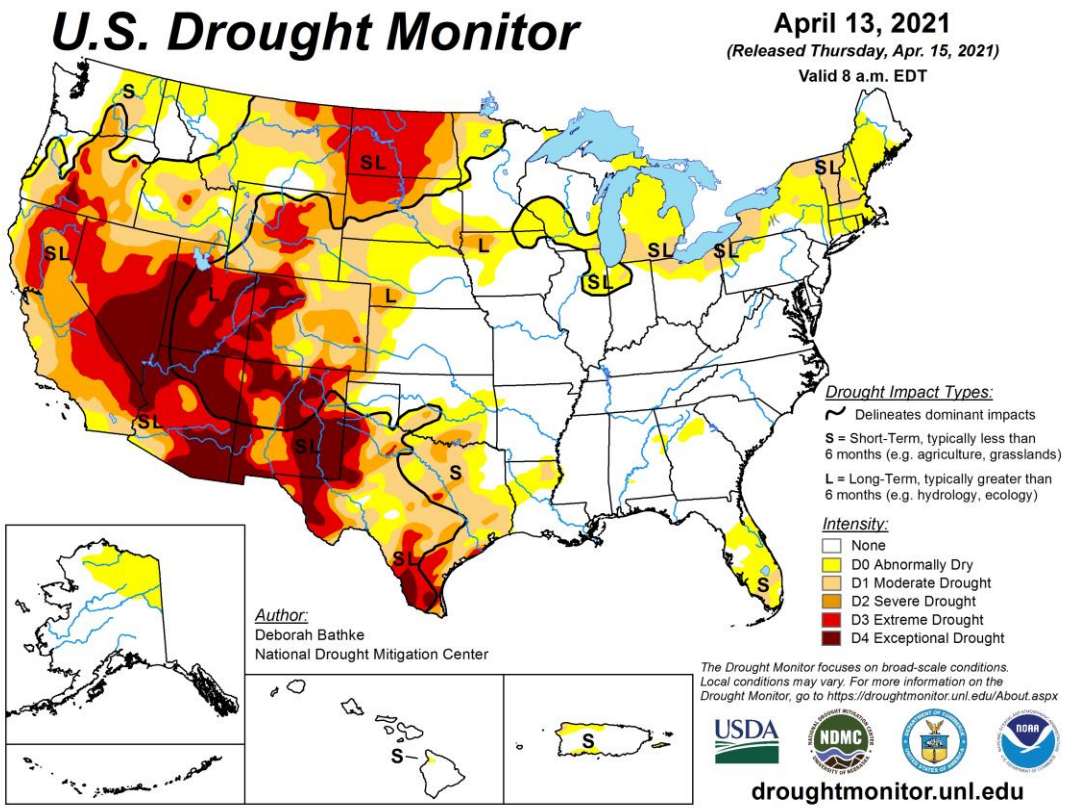
National Integrated Drought Information System

USGCRP - US GEWEX
SOIL MOISTURE MINI WORKSHOP

VEVA DEHEZA | APR 16 2020

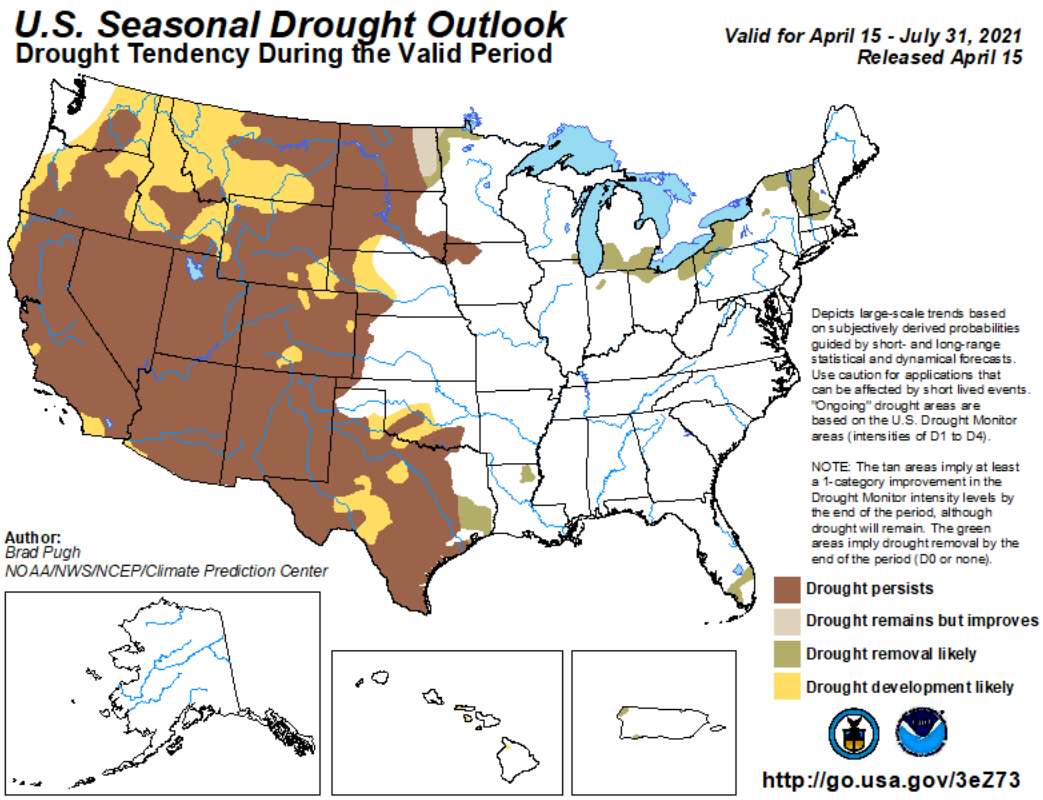
U.S. Drought Monitor

April 15, 2021



U.S. Seasonal Drought Outlook

Valid for April 15 - July 31, 2021



NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS)

MISSION + ACTIVITIES

Regional Drought Early Warning Systems

Prediction and Forecasting

Integrated Research and Monitoring

Drought Planning and Preparedness

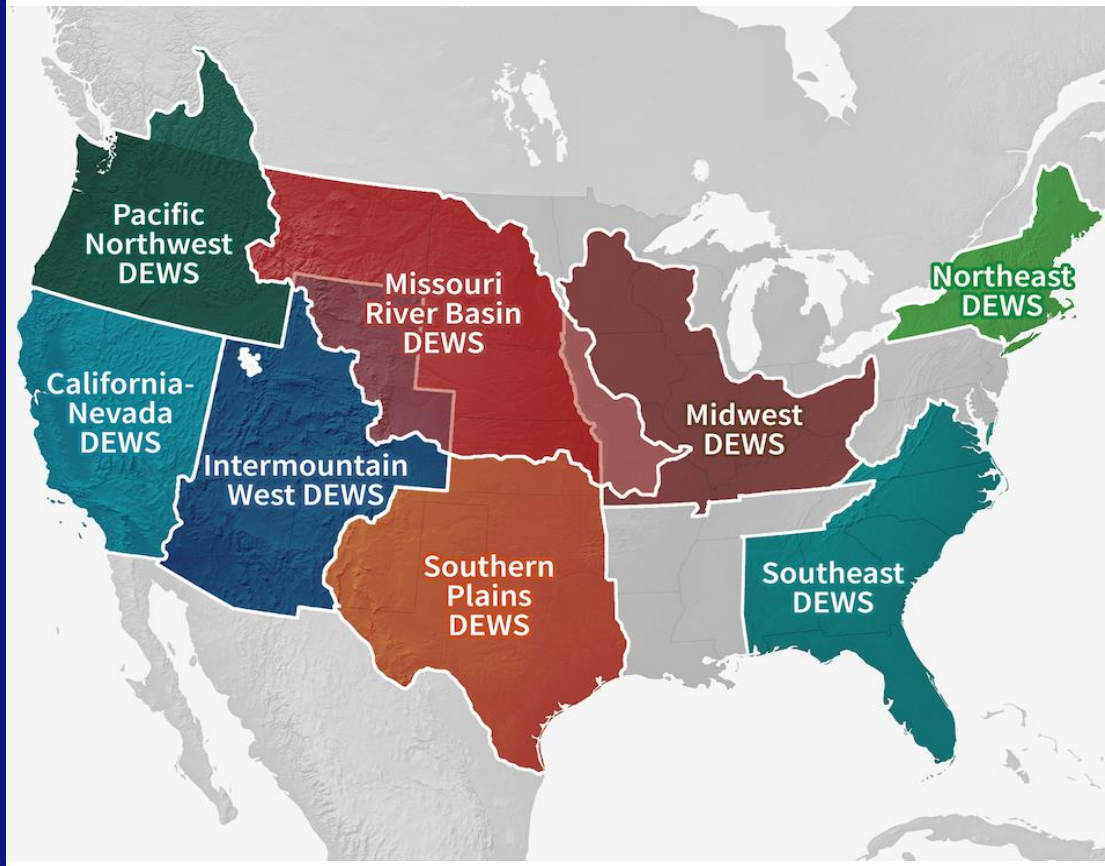
Collaboration with Existing Programs and Partners

The U.S. Drought Portal (www.drought.gov)

REGIONS

Drought Early Warning

A Drought Early Warning System (DEWS) utilizes new and existing networks of federal, tribal, state, local and academic partners to make climate and drought science accessible and useful for decision makers.



APPROACH

Drought Early Warning

"A system that collects and **integrates information** on the key indicators of drought in order to make usable, reliable, and timely drought forecasts and assessments of drought…..

…and **communicates drought forecasts, conditions, and impacts** on an ongoing basis to decision makers, the private sector, and the public."

NIDIS Public Law 109-430

Reauthorization

On January 7, 2019, the President signed S.2200 into law, the National Integrated Drought Information System (NIDIS) Reauthorization Act (Pub. L. 115-423):

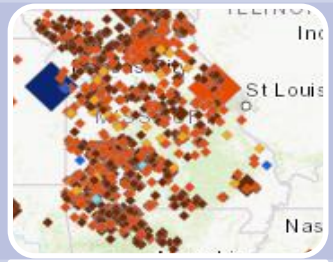
- Authorizes funding for NIDIS to increase from $13.5 million in fiscal year 2019 to $14.5 million in fiscal year 2023
- Authorizes NIDIS to engage in partnerships with the private sector, academic institutions, and citizen scientists
- NIDIS will provide timely data, information, and products that reflect watershed differences in drought conditions
- Calls for NIDIS to support improvements in seasonal, subseasonal, and low flow water prediction
- **Directs NOAA to develop a strategy for a national coordinated soil moisture monitoring network.**

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS)

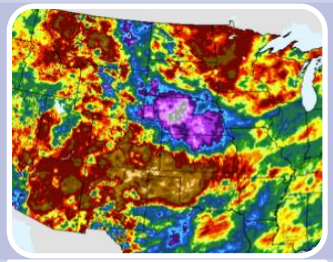
NIDIS in Action Across Regions

Drought & Public Health

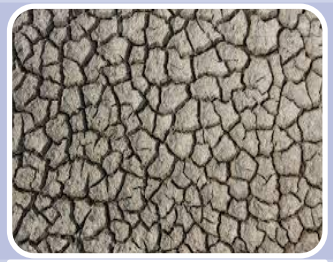
Drought and Wildfire



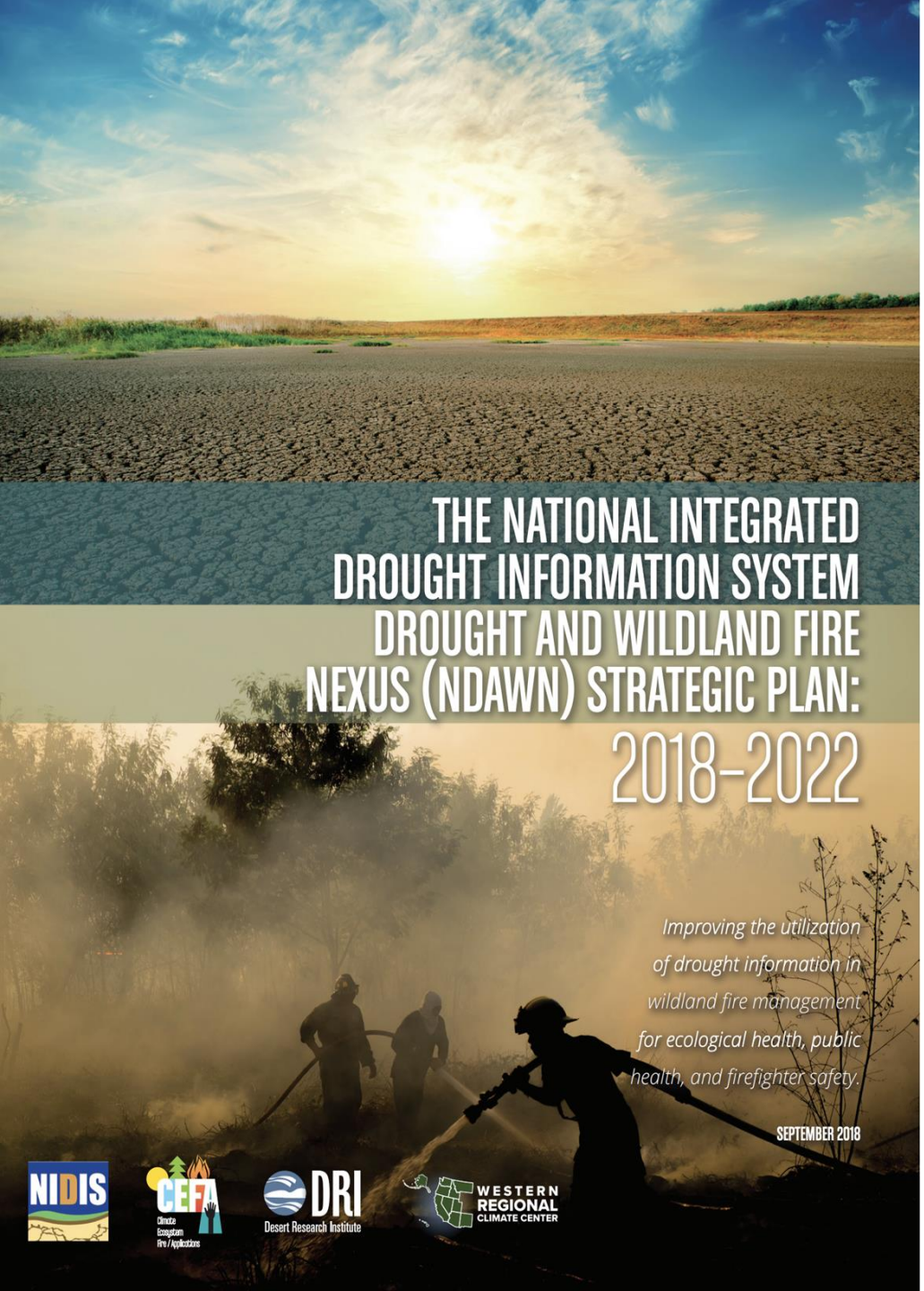
Drought Impact Reporting and Analysis



Drought Indicators and Triggers



National Soil Moisture Network



NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS)

NIDIS and Fire Community Release Drought and Wildland Fire Nexus Strategic Plan: 2018-2022

To improve the utilization of drought information in wildland fire management for ecological health, public health, and firefighter safety.

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS)

Drought Impact Assessments: The Northern Plains Drought of 2017

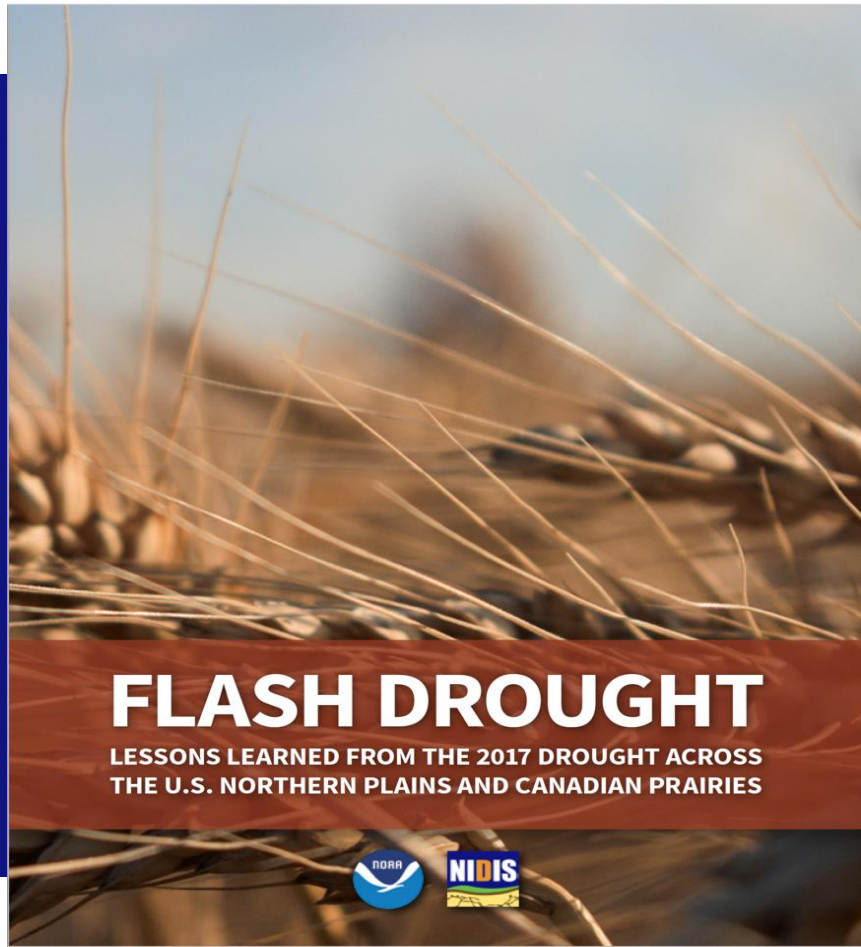
U.S. agricultural losses of over $2.6 billion.

Livestock production was especially hard-hit due to the widespread scarcity of feed and water.

4,837,599 acres burned across the U.S. Northern Plains and Canadian Prairies.

Despite near-normal stream flows for the entire 2017 season, water supply to rural water providers was reduced in some areas.

Tribal cultural resources were impacted, putting these resources at risk for future generations.



Virtual Flash Drought Workshop

December 2020

- Agree on the **basic set of characteristics** of flash drought, including definitions by sector, region, and application
- Document how **existing flash drought tools and research** can meet user needs both in the near-term and in the future
- Develop a list of **outstanding research needs** in monitoring, prediction, and planning/response to improve early warning
- Agree on next steps for this emerging domain and how NIDIS and other partners can support **research and coordination**

National Coordinated Soil Moisture Monitoring Network (NCSMMN)

Coordinated, high-quality, nationwide soil moisture information for the public good

- Network of Networks
  - State mesonets
  - Federal – e.g., USDA SCAN, NOAA USCRN
  - … Other (Private, Citizen Science)
  - …. And Satellites / Modeling systems
- Network of People
  - Partnering agencies at federal and state levels
  - Research & end user community: 150 members+

NOAA USDA USGS science for a changing world NIDIS NASA Oklahoma State University The Ohio State University NDMC Colorado State University Mesonet at SDSTATE

Drought.gov Re-Launch

Major new features:

- City, county, and watershed level conditions
- New, up-to-date drought statistics
- Historical data and maps
- “By Sector” pages detailing Impacts and Resources
- “Research and Learn” section

National Integrated Drought Information System

Drought.gov

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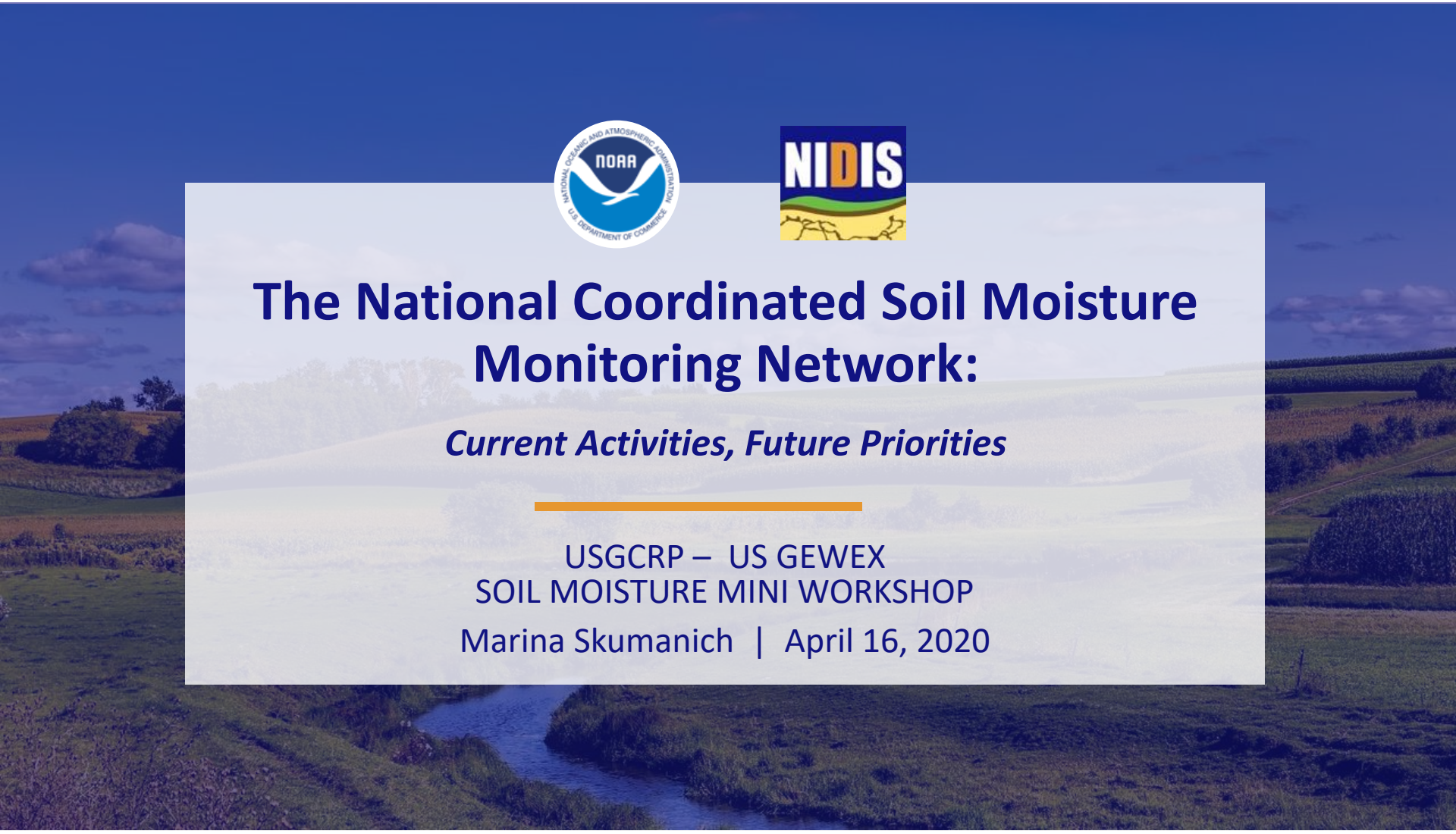


The National Coordinated Soil Moisture Monitoring Network:

Current Activities, Future Priorities

USGCRP – US GEWEX
SOIL MOISTURE MINI WORKSHOP

Marina Skumanich | April 16, 2020

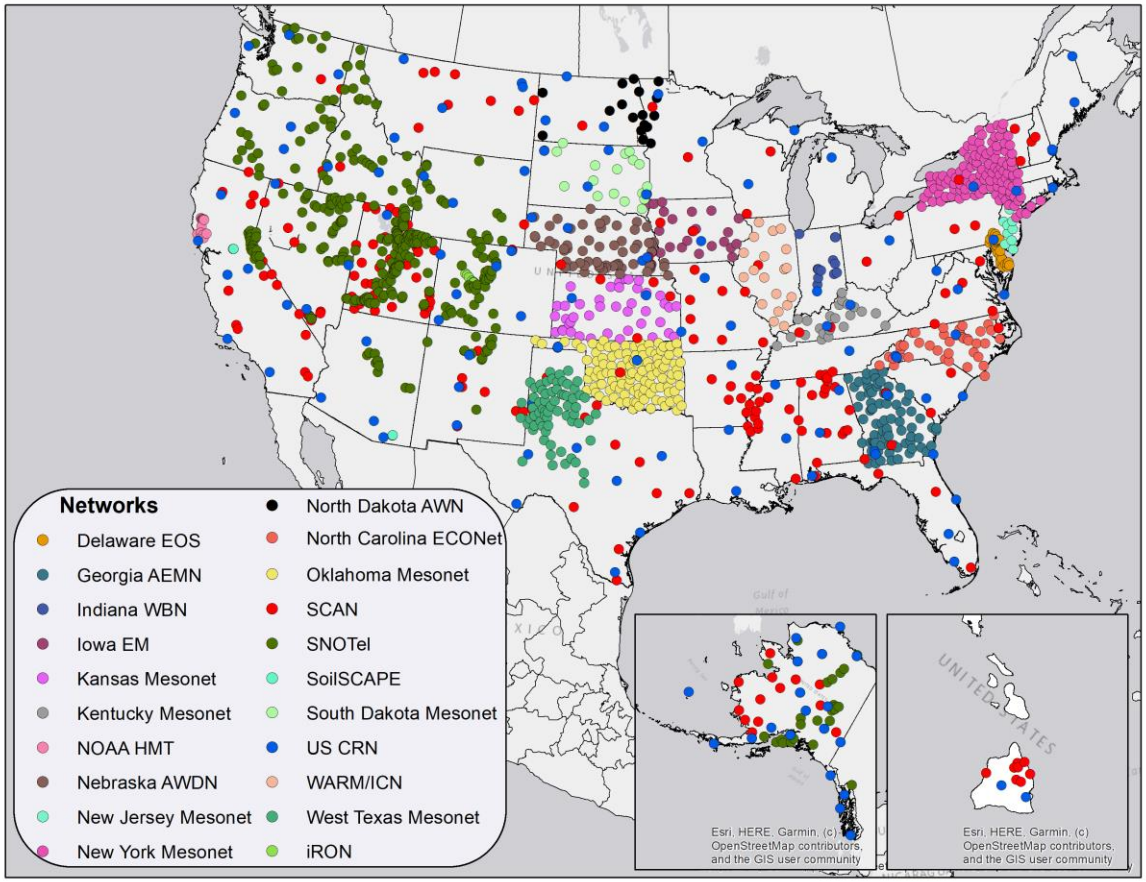
National Coordinated Soil Moisture Monitoring Network "NCSMMN"

Coordinated, high-quality, nationwide soil moisture information for the public good

- Network of Networks
  - State mesonets
  - Federal – e.g., USDA SCAN, NOAA USCRN
  - … Other (private, citizen science)
  - …. And satellites / modeling systems
- Network of People
  - Partnering agencies at federal and state levels
  - Research & end user community

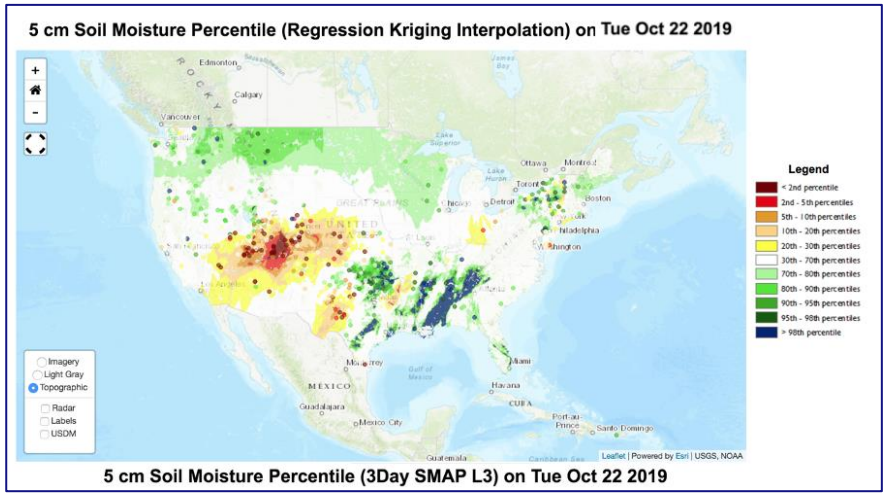
NOAA · USDA · USGS science for a changing world · NIDIS · NASA · Oklahoma State University · The Ohio State University · NDMC · Colorado State University · Mesonet at SDSTATE

U.S. Soil Moisture Networks



What “Soil Moisture Information” ?

- **Products:** Real time, gridded, high-res. soil moisture maps, blending:
  - In situ data
  - Remote sensing data
  - Model outputs



- **Technical Assistance Materials**
  - “Planning Guide for Installing and Maintaining Soil Moisture Stations”
- **Standards**
  - Data-quality criteria for *in situ* networks
  - Sensor performance standards
- ***And… ?***

Builds on Previous Activities

- 2010: Marena, Oklahoma *In Situ* Sensor Testbed (MOISST)
- Soil Moisture Monitoring Workshops / Reports
  - 2013: Kansas City, MO
  - 2016: Boulder, CO
  - 2018: Lincoln, NE
  - 2019: Manhattan, KS
  - 2020: Virtual
- 2018 Congressional Mandate:
  - *"NIDIS… shall develop a strategy…"*
  - Executive Committee formed

2011

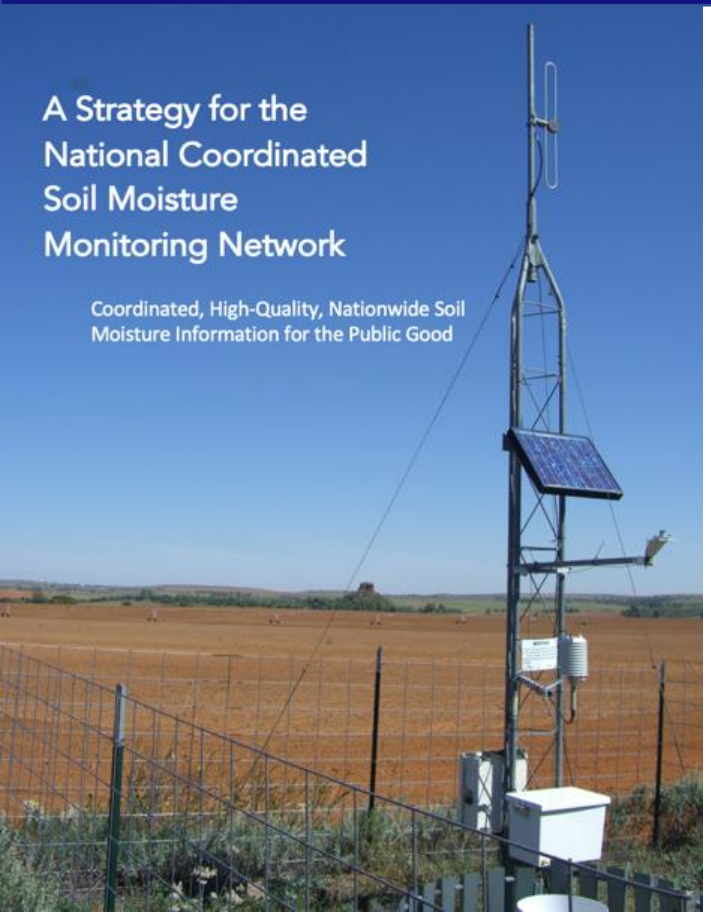
2016

2019

NCSMMN Executive Committee

Name	Affiliation
Bruce Baker	NOAA ARL
John Bolten	NASA Goddard
Mark Brusberg	USDA Office of the Chief Economist
Todd Caldwell	USGS Nevada Water Science Center
Stephanie Connelly	USDA USFS
Michael Cosh, Chair	**USDA ARS**
Veva Deheza	NOAA NIDIS
Nathan Edwards	South Dakota Mesonet
Heather Hofman	USDA NRCS
Peter Goble	CoCoRaHs
Tyson Ochsner	Oklahoma State University
Steven Quiring	Ohio State University
Marina Skumanich	NOAA NIDIS
Mark Svoboda	National Drought Mitigation Center (UN-Lincoln)
Molly Woloszyn	NOAA NIDIS Midwest DEWS

A Strategy for the NCSMMN

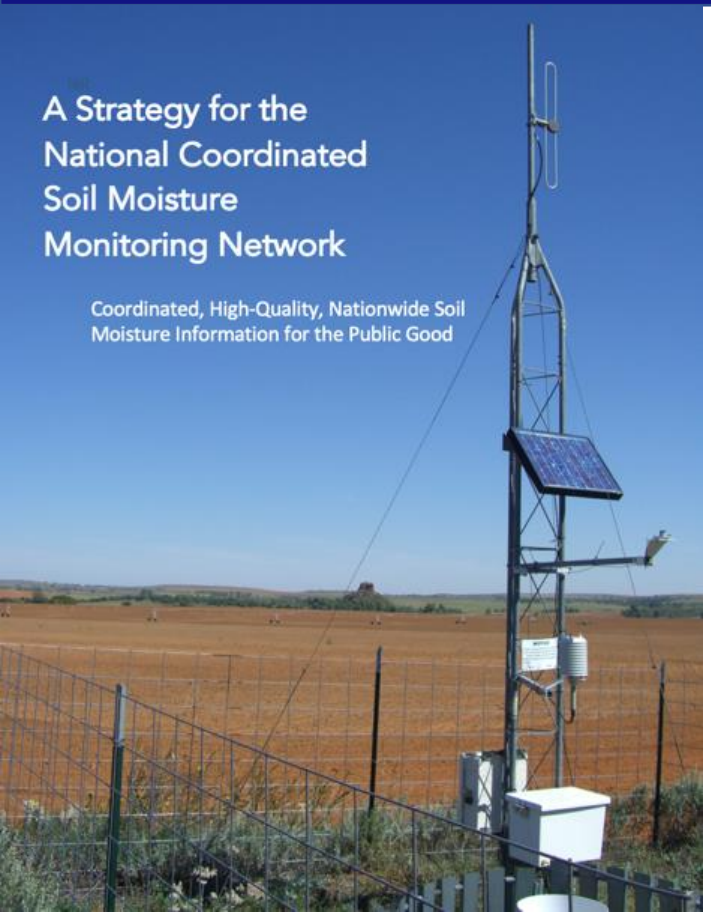


*A **roadmap forward** and **resources needed** to build a coordinated network of networks*

Key Recommendations:

1. **Formalize and expand partnerships**
   - Data providers (Mesonets, private nets, citizen science)
   - End users of NCSMMN products
2. Work to **expand *in situ* soil moisture monitoring**
   - USACE Upper Missouri River Basin project
   - SE Region: AL, GA, FL Buildout
   - Forests, rangelands
3. Develop **priority list of criteria** for high-quality data
   - Including metadata – e.g., soil characterization

A Strategy for the NCSMMN *(cont'd)*



Recommendations *(cont'd)*:

4. **Support research** to develop/improve NCSMMN methodologies
   - Interpolating soil moisture data
   - "Blending" data sources (*in situ*, satellite, model)
   - Validation and QC

5. Develop **real-time, high-resolution, gridded national maps**, and other user-friendly products
   - NationalSoilMoisture.com
   - NOAA ARL: SWAMP – *on the way!*

Possible Engagement with USGCRP / US GEWEX

- Identifying synergies across the various initiatives – how do we all fit together?
- Doing strategic cross-promotion – what are we missing that would make our case(s) stronger?
- Making effective connections beyond federal system
  - State agencies, universities & research centers, private sector, citizen science
  - Internationally

Thank you

Questions/comments – email me!

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Federal
Soil Moisture Working Group

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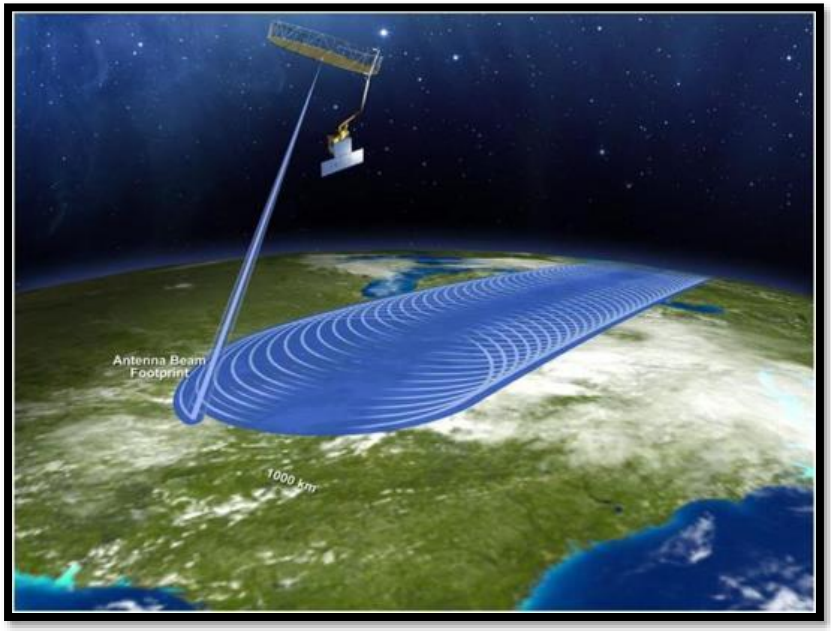
NASA Soil Moisture Active Passive Mission launched in 2015



NASA Soil Moisture Active Passive
Early Adopter Program
Led by Susan Moran, USDA-ARS

Early Adopters included

NOAA
USFS*
NASS*
FAS*
DOD
NDMC

From 2015-2020 Memorandum of Understanding between USDA and NASA

INTERAGENCY ANNEX NO. 1
between the
U.S. DEPARTMENT OF AGRICULTURE
and the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

UNDER UMBRELLA INTERAGENCY AGREEMENT No. 13554

1.0 PURPOSE OF ANNEX

The purpose of this Annex is to identify specific research and application activities that NASA and the U.S. Department of Agriculture (USDA), specifically, the USDA Agriculture Research Service (ARS) and the NASA Science Mission Directorate (SMD), Earth Science Division (ESD), Applied Sciences Program (ASP) will pursue related to soil moisture and freeze/thaw state that are consistent with their mutual interests and shared objectives.

From 2015-2020 Memorandum of Understanding between USDA and NASA

4.0 RESPONSIBILITIES

A. NASA will use reasonable efforts to:
   1. Coordinate soil moisture science, applications, and mission products with USDA.
   2. Provide access to calibration/validation, algorithms, and applied research related to soil moisture to USDA.
   3. Form a soil moisture team to work with USDA soil moisture scientists and practitioners.

B. USDA will use reasonable efforts to:
   1. Coordinate USDA projects using and needing soil moisture information from NASA.
   2. Establish soil moisture liaisons with NASA to coordinate with NASA soil moisture projects and missions.
   3. Form a USDA soil moisture working group to coordinate USDA cooperation with soil moisture projects and missions.

5.0 SCHEDULE AND MILESTONES

The planned major milestones for the activities in the Annex defined in the "Responsibilities" Article are as follows:

Establish USDA soil moisture liaisons – March, 2017
Form a NASA soil moisture team – March, 2017
Form a USDA Soil Moisture Working Group – June, 2017

Quarterly to Bi-Monthly Meeting

Topics have included:

- Soil Moisture Active Passive Mission
- NASA ISRO Synthetic Aperture Radar Mission
- Consortium of Universities for the Advancement of Hydrologic Science, Inc.
- USGS Next Generation Water Observing System
- National Ecological Observing Network
- Community Collaborative Rain, Hail & Snow Network (CoCoRaHS)
- American Association of State Climatologists
- Soil Survey
- Soil Climate Analysis Network
- Climate Reference Network
- On Farm Network Technologies
- National Water Model

Attending Agencies

USDA: ARS, NASS, FAS, OCE, FS, NIFA, NRCS, RMA

NASA GSFC, JPL

DoE: ARM program

DoD: Army Corps of Engineerg, Army Research Laboratory

NOAA, CRN, NIDIS, ATDD, NESDIS

USGS

Upcoming Meetings

Soil Moisture End Users Listening Sessions	Summer 2021
National Soil Moisture Workshop, Beltsville, MD	August 18-19, 2021
Geological Society of America, Portland, OR	October, 2021
ASA-CSSA-SSSA, Salt Lake City, UT	November 2021
American Geophysical Union, New Orleans	December 2021
American Meteorological Society, Houston, TX	January 2022
Spring AGU Hydrology Meeting (TBD)	Spring 2022
6th Soil Moisture Applications and Validation Workshop Perugia, Italy, Hybrid-Virtual(US)	(Summer 2022)

USDA NASA MOU 2020-2024

MEMORANDUM OF UNDERSTANDING

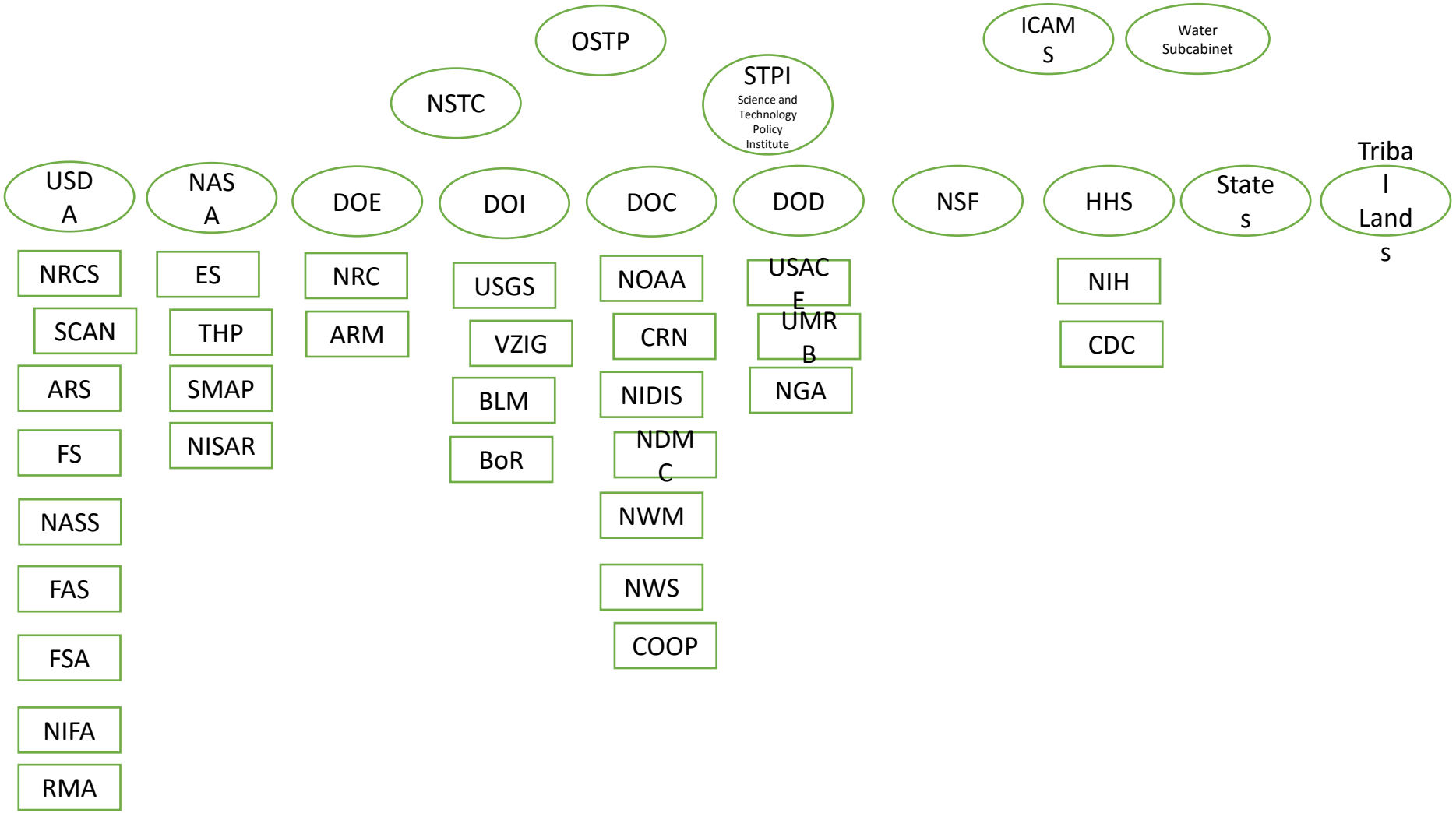
between the

U.S. DEPARTMENT OF AGRICULTURE
and the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
for
COOPERATION TO ADVANCE EXPLORATION, AGRICULTURAL AND EARTH SCIENCES APPLICATIONS, TECHNOLOGY, AND EDUCATIONAL ACTIVITIES

I. BACKGROUND AND PURPOSE

This Memorandum of Understanding ("MOU") between the U.S. Department of Agriculture ("USDA") and the National Aeronautics and Space Administration ("NASA") (NASA and the USDA may be individually referred to as a "Party" and collectively as the "Parties") establishes the Parties' intent to continue their existing cooperative relationship and to promote additional opportunities for collaboration between the Parties.

NASA and the USDA enjoy a longstanding history of joint efforts to improve agricultural and Earth science research, technology, and agricultural management, as well as the application of science data and models to agricultural decision making. NASA and the USDA also have worked together on education, communication, and outreach activities to inspire youth in America to pursue careers in science, technology, engineering, and mathematics ("STEM") and agriculture.


OSTP
ICAMS
Water Subcabinet
NSTC
STPI
Science and Technology Policy Institute
Tribal Lands
USDA
NASA
DOE
DOI
DOC
DOD
NSF
HHS
States
NRCS
SCAN
ARS
FS
NASS
FAS
FSA
NIFA
RMA
ES
THP
SMAP
NISAR
NRC
ARM
USGS
VZIG
BLM
BoR
NOAA
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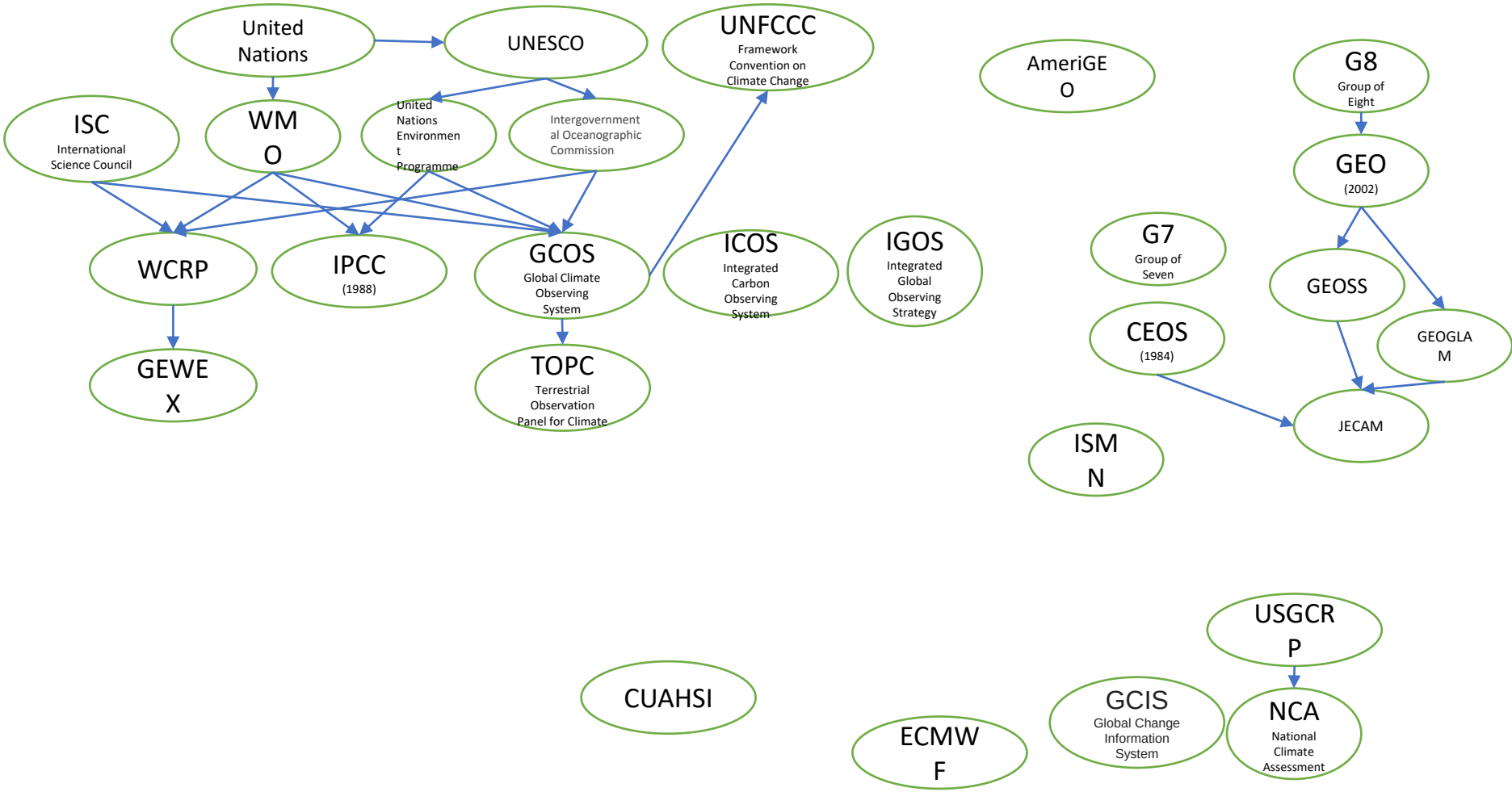
USACE
UMRB
NGA
NIH
CDC


United Nations
UNESCO
UNFCCC
Framework Convention on Climate Change
ISC
International Science Council
WMO
United Nations Environment Programme
Intergovernmental Oceanographic Commission
WCRP
IPCC
(1988)
GCOS
Global Climate Observing System
ICOS
Integrated Carbon Observing System
IGOS
Integrated Global Observing Strategy
GEWEX
TOPC
Terrestrial Observation Panel for Climate
AmeriGEO
G8
Group of Eight
GEO
(2002)
G7
Group of Seven
GEOSS
CEOS
(1984)
GEOGLAM
JECAM
ISMN
CUAHSI
USGCRP
GCIS
Global Change Information System
NCA
National Climate Assessment
ECMWF

AmeriFlux and Soil Moisture

Participating today:

Russ Scott — USDA ARS
Past co-chair of AmeriFlux Science Steering Committee

Marcy Litvak — University of New Mexico
Co-chair of AmeriFlux Science Steering Committee
Co-chair of Water Year Organizing Committee

Sebastien Biraud — Berkeley Lab
Deputy lead of the AmeriFlux Management Project

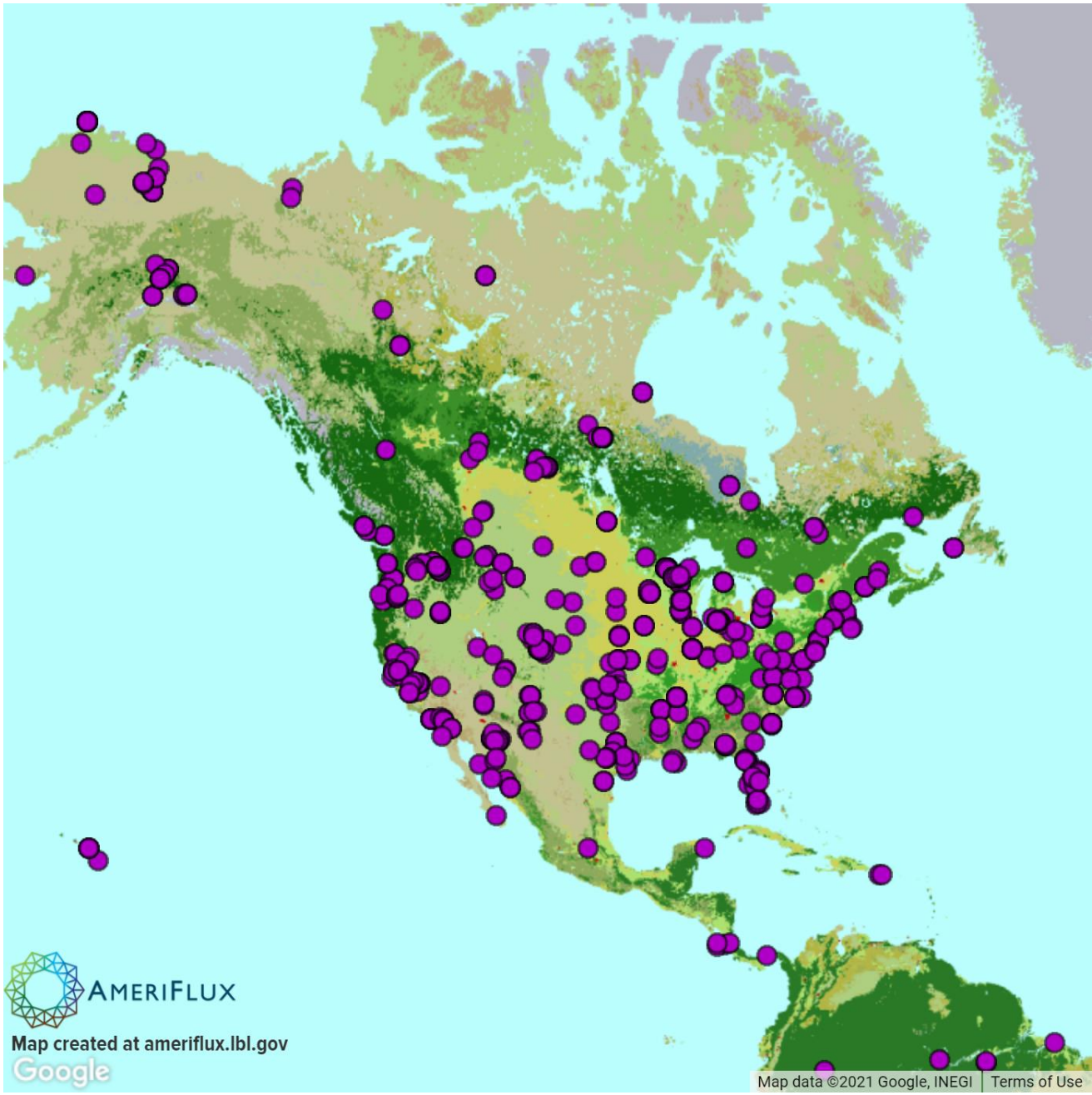
GEWEX April 16, 2021

The AmeriFlux Network

8,000 scientists **using eddy covariance data** **523 sites**

3,466 unique data users **2,463 Site-years of data from 368 sites**

The AmeriFlux N. American Sites



AMERIFLUX

People and Partners

USDA FOREST SERVICE NASA NSF NOAA U.S. DEPARTMENT OF THE INTERIOR UNITED STATES ENVIRONMENTAL PROTECTION AGENCY FLUXNET A Global Network ICOS INTEGRATED CARBON OBSERVATION SYSTEM

neon National Ecological Observatory Network, Inc.

WMO, NIST, NREL, Phenocam, and many more!

AmeriFlux Management Project

DOE-supported project to serve the whole network.
We provide:

- **Data Support**
- **Tech Support**
- **Core Sites**
- **Outreach**

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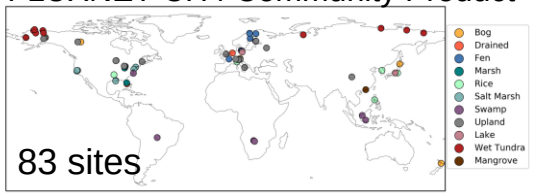
Our first theme for network action, started 2018

Year of Methane

AMERIFLUX

FLUXNET-CH4 Community Product



https://fluxnet.org/data/fluxnet-ch4-community-product/

Doubled number of CH4-measuring sites

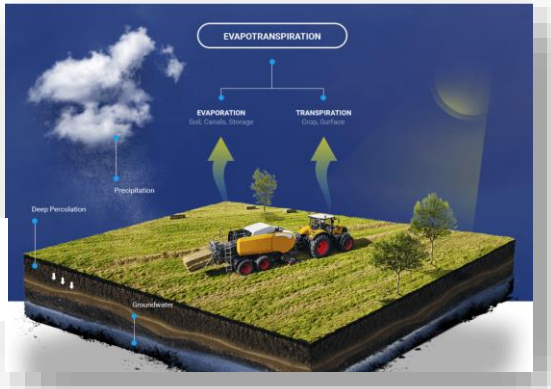
Our new theme for network action
Launched March 2021

Many science themes for Water in AmeriFlux

Soybeans in drought

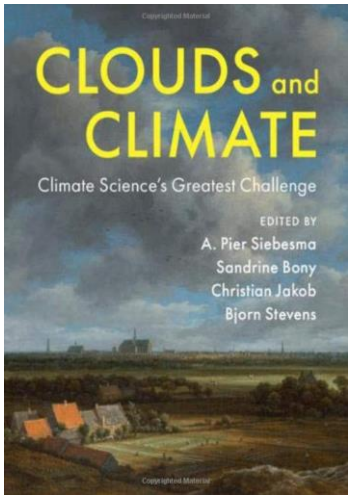
Coupled carbon and water cycles

Remote sensing (ET, soil moisture)



OPEN ET

Land and water management



Boundary layer dynamics and weather

Upcoming activities – Year of Water Fluxes

- FLUXNET Early Career Network Workshop on Water Fluxes, April 15-16, (open to all, but aim is to support and highlight early career researchers)
- Workshop on the Boundary Layer and Land-Atmosphere Interactions, June 10-11
- Call for Papers on Advances in Scaling and Modeling of Land-Atmosphere Interactions, multi-journal AGU collection.
- Mini-workshop series on sensors and water cycle measurements, starting in May
- Summer workshop on evapotranspiration synthesis and partitioning. Contact Trevor.Keenan@lbl.gov.
- The AmeriFlux Management Project (AMP) is submitting a proposal to DOE in April to purchase water-cycle sensors for U.S. AmeriFlux sites.

Upcoming activities – Year of Water Fluxes

- Organizing Committee for Year of Water Fluxes
- AmeriFlux postdoc based in Berkeley. Position is open now, applications are being reviewed in April.

Many Potential Partners & Audiences

- NASA: ECOSTRESS, GRACE, SMAP, SMOS, COSMOS
- DOE ASR, ARM: Boundary layer dynamics and precipitation
- NOAA: Weather and evapotranspiration
- Integrated Interagency Water Cycle Group, GEWEX
- USDA: LTAR; National soil moisture network (proposed)
- USGS
- Projects and Companies: OpenET

Questions posed for this meeting - 1

1. What is the rationale for the soil moisture measurements and/or products your group develops? Are you targeting research and/or operational application?

Research

2. Do you take or provide any co-located and/or related data in addition to soil moisture? For example, co-located atmospheric or flux measurements, ecological or hydrologic observations, etc.

Yes

Discuss

3. What enhancements could provide additional scientific value and value to stakeholders? (e.g. additional variable measurements, additional sites, increased resolution of products, etc.)

With the Water Year, we are improving hydrological instrumentation at numerous sites. e.g., soil moisture, soil water potential, water table depth, improved precip gauges.

Providing data quicker

Adding flux towers to high priority sites

Discuss

4. Do you have priorities, strategies or plans for any of these enhancements?

   a) With which other groups would collaboration add value to you or your stakeholders?

NEON (longer term records to contextualize NEON obs.)

GEWEX (involvement in Regional Hydrometeorology Groups)

Federal Soil Moisture Working Group (AF fluxes to understand how SM translates to water and carbon cycling)

NASA – Cal/Val activities, SMAP, Airmoss, Cygnus, MODIS

   a) How can USGCRP / US GEWEX best engage you going forward?

Participate/present in AF annual meeting

Perhaps formal collaborations with DOE if would be useful

Discuss

What questions, ideas, or topics do you have for the meeting participants (e.g. other groups, U.S. agencies) that you would like to discuss or pursue together?

Timing of data availability (how soon do other agencies need AF data?)

Would formal collaborations/agreements be of interest?

Ways we can expand AF observations to be of greater benefit?

Discuss

2020 AmeriFlux Annual Meeting: *virtually* bridging the Americas
280 attendees from 32 countries

2021 AmeriFlux Annual Meeting: bridges to other water-related networks?

Poster session and meet-ups in **Gather**

Plenary and breakout sessions in **Zoom**

Virtual US GEWEX in-situ soil moisture briefings and roundtable
16 April 2021

NEON's soil moisture sensor data

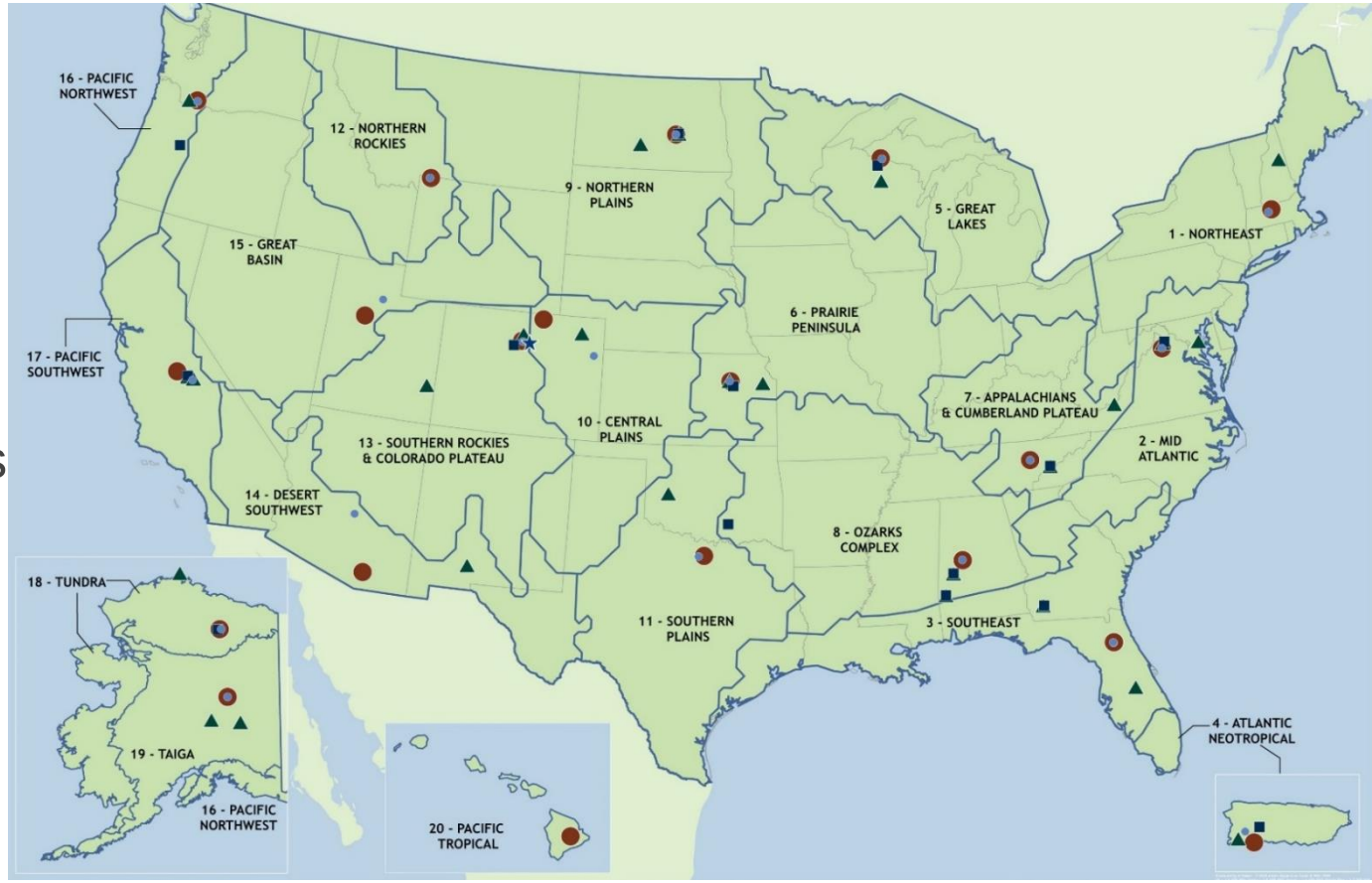
Dr Edward Ayres

Soil sensor measurements lead & Megapit Soil Archive manager

This material is based upon work supported by NSF's National Ecological Observatory Network which is a major facility fully funded by the National Science Foundation

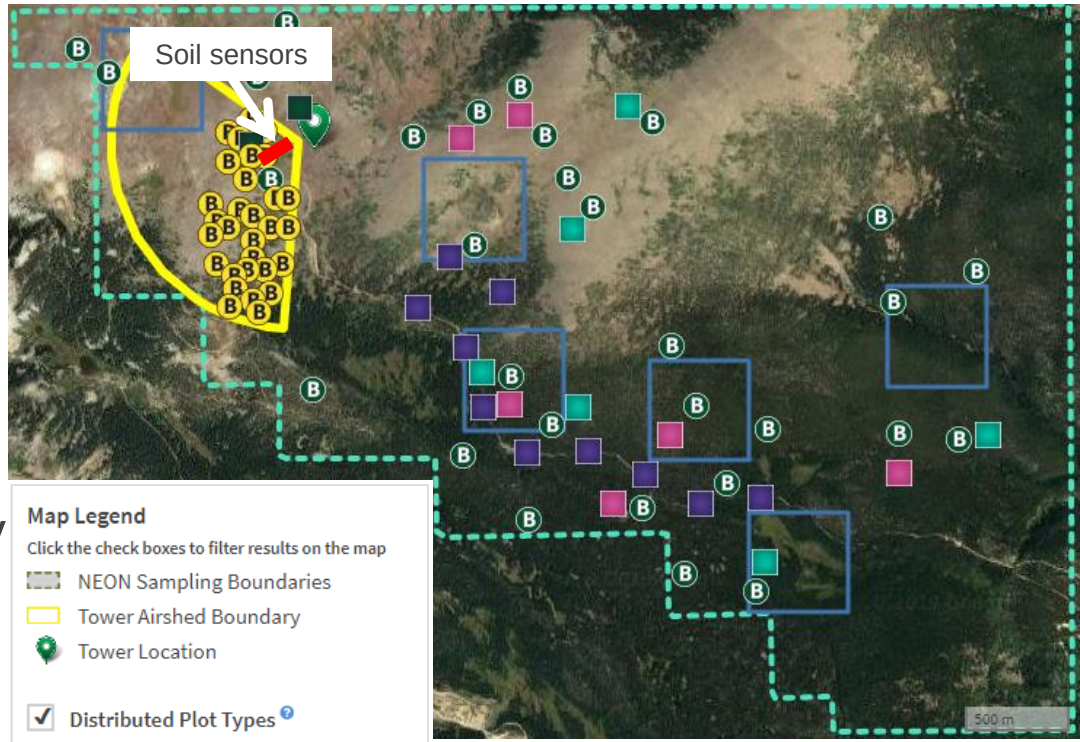
NEON overview

- 81 sites
  - 47 terrestrial
  - 34 aquatic
- Spans major US biomes
- ~180 data products
  - In-situ sensors
  - Field crews
  - Remote sensing aircraft
- Sample archives
  - ~100,000 per year
- All data and archived samples freely available www.neonscience.org/



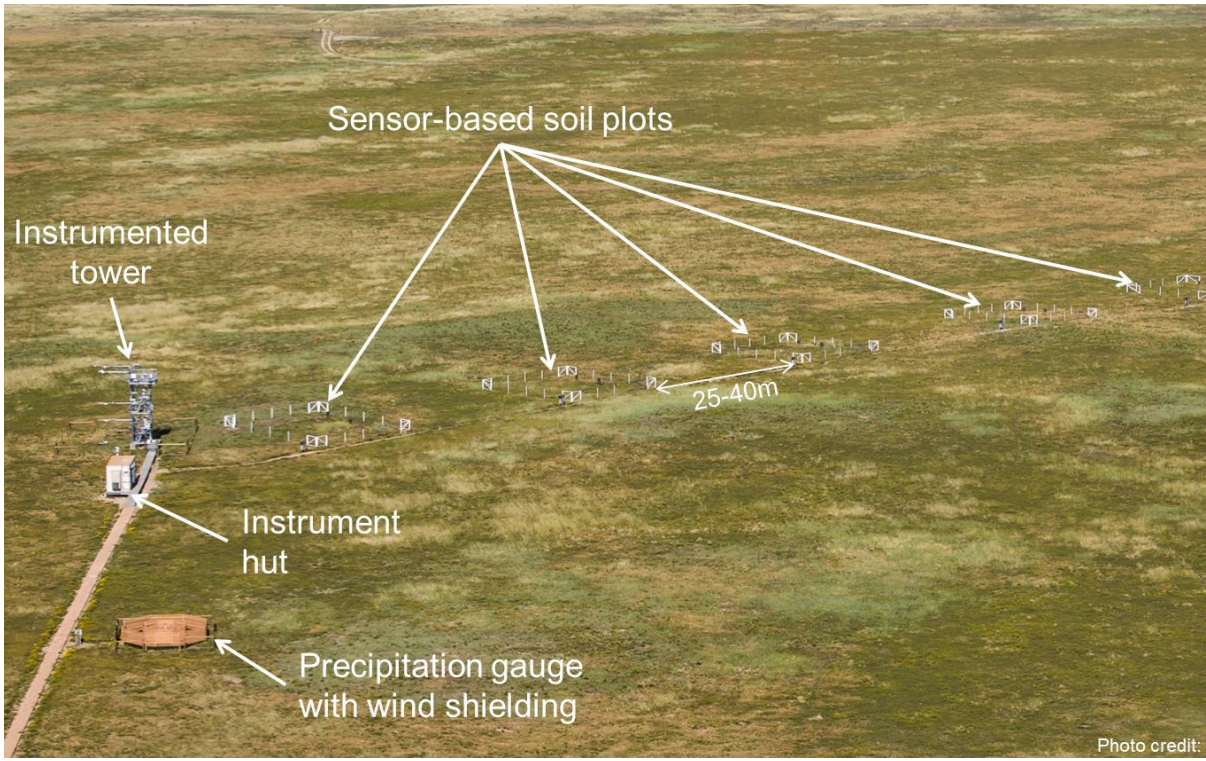
Terrestrial site layout

- Range of spatial scales
  - Sensors: <1 km^2
  - Field crews: ~10-50 km^2
  - Remote sensing: ~150 km^2
- Field crews
  - Plant productivity & phenology
  - Soil & plant biogeochemistry
  - Biodiversity
    - Soil microbes, plants, beetles, birds, mammals, ticks
- Remote sensing
  - Photos, LIDAR, hyperspectral



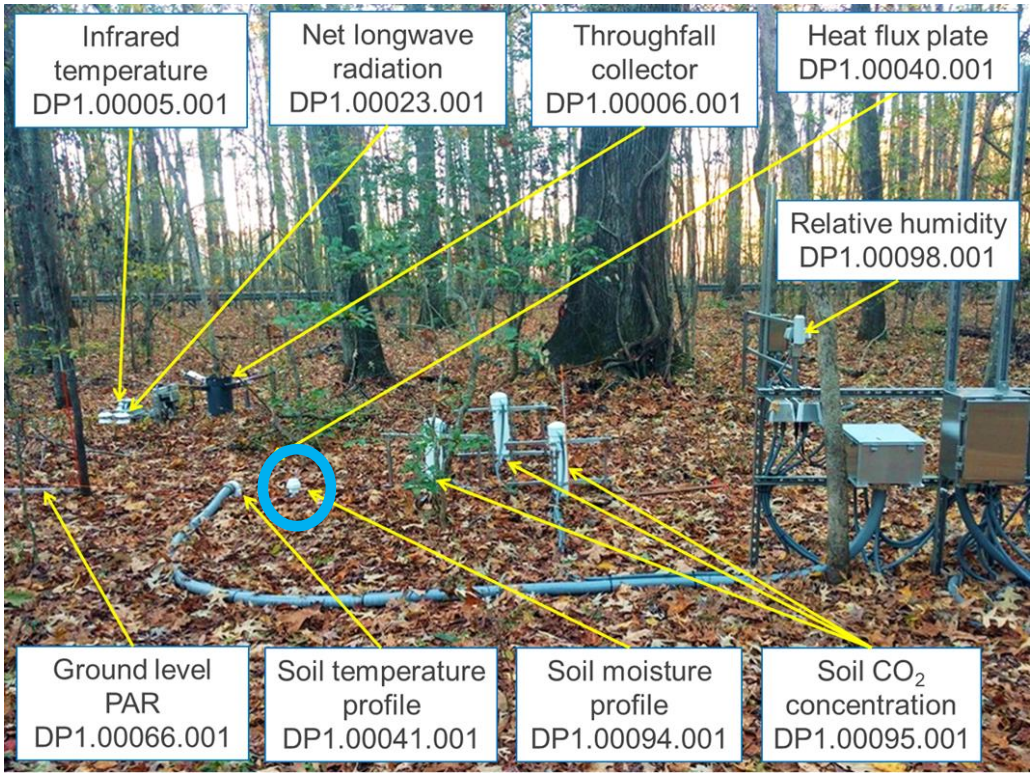
Terrestrial sensor layout

- One instrumented tower
  - Meteorology
  - Eddy covariance
  - Phenocams
  - And more…
- Five soil plots per site
- 25-40 m apart
- Typically located in:
  - Locally dominant soil type
  - Tower airshed
- One soil moisture profile per plot



Soil water content

- Vertical profiles up to 2 m deep
- Up to 8 depths (if soil allows)
  - Depths vary based on soil depth & horizons, but usually include:
    - 6, 16, 26,…196 cm
- Sensor: Sentek EnviroSCAN TriSCAN (capacitance-type sensor)
- Calibrated in air and water annually
- Data available as 1-min & 30-min averages
  - https://data.neonscience.org/data-products/DP1.00094.001

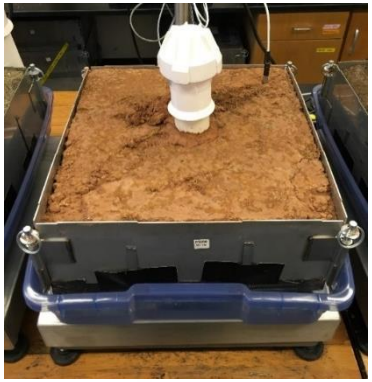


Soil sample collection for soil-specific calibrations

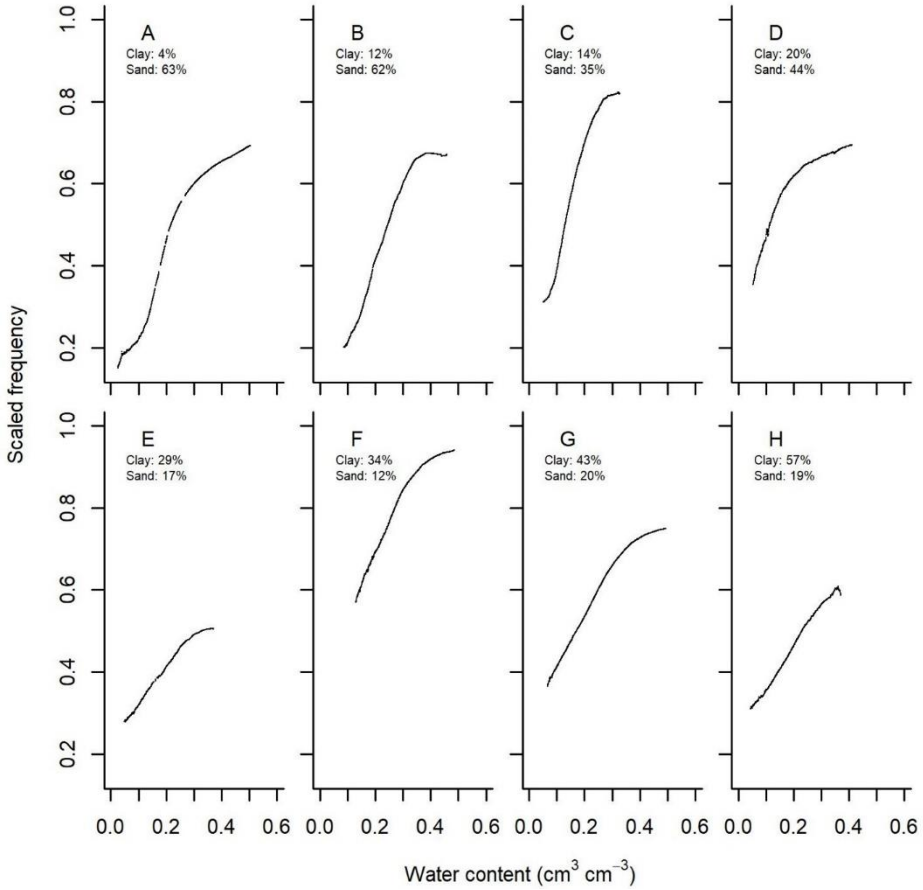
- One temporary soil pit per site
  - Up to 2 m deep
- Intact soil blocks collected
  - Up to 6 per pit
- Other soil pit samples & data
  - Soil taxonomy, description, and photos
    - https://data.neonscience.org/megapit-info
  - Soil physical & chemical properties (DP1.00096.001) & root biomass (DP1.10066.001)
  - Megapit Soil Archive
    - https://www.neonscience.org/samples/soil-archive

Roberti et al. 2018 Vadose Zone J. 17:170-177. doi:10.2136/vzj2017.10.0177

Dry-downs



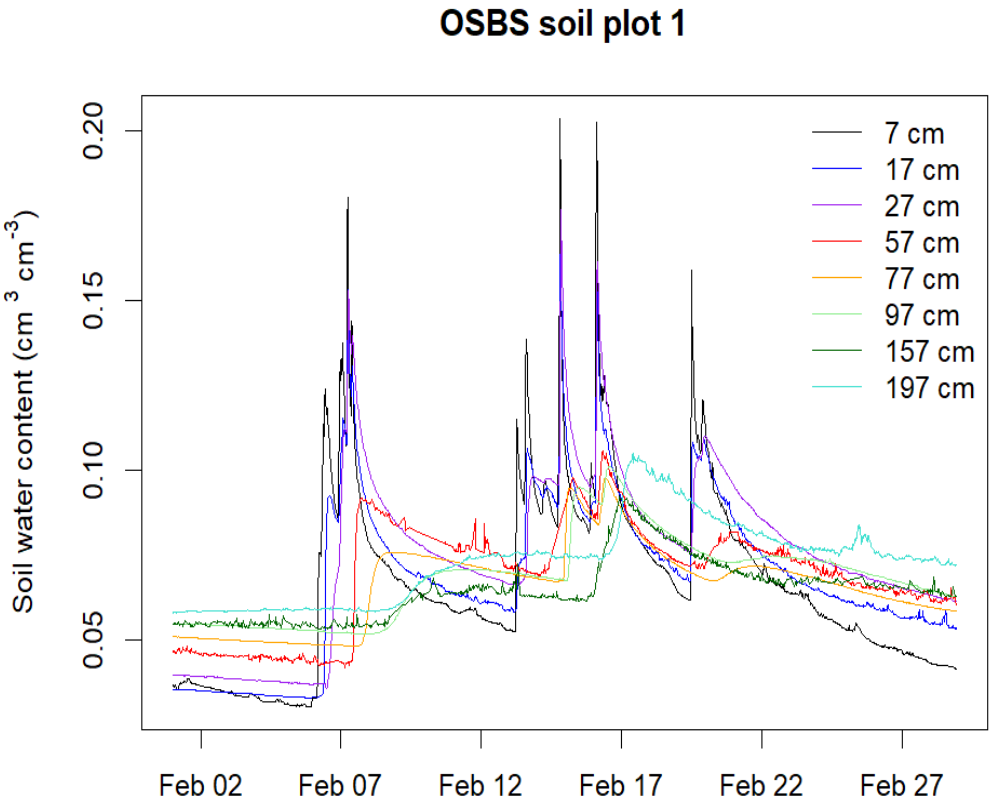
- Sensor installed in soil block
- Soil placed on scale
  - Gravimetrically determine soil water content
- Soil block saturated
- Dried by evaporation until weight approached asymptote
  - ~2.5 months
- Repeated for 235 soil blocks



Roberti et al. 2018 Vadose Zone J. 17:170-177. doi:10.2136/vzj2017.10.0177

Soil water content data product

- Automated QA/QC tests
  - Step, range, persistence, spike, gap, temperature tests
- Optional manual flagging as necessary
- Data published with a final quality flag
  - 0 = considered trustworthy
  - 1 = potentially suspect
- Data portal
  - https://data.neonscience.org/home
- Soil moisture data
  - https://data.neonscience.org/data-products/DP1.00094.001



Other selected NEON soil data and samples

Plus ~150 other products

- Soil water content and salinity
- Soil temperature
- Soil heat flux
- Soil CO_2 concentration
- Soil/litter/vegetation surface temperature
- Ground level PAR
- Precipitation & throughfall

- Root biomass & chemistry
  - Megapit: 0-2 m, one time
  - Periodic: 0-30 cm, every 5 yr

- Litter production and chemistry

- Soil physical and chemical properties
  - Megapit:
    - 0-2 m, one location, one time, by horizon
  - Distributed Initial Characterization:
    - 0-1 m, ~10 locations, one time, by horizon
  - Periodic:
    - 0-30 cm, ~20 locations, three times/yr, mineral or organic

- Soil microbial
  - biomass
  - metagenomes
  - group abundances
  - community composition
  - marker gene sequences

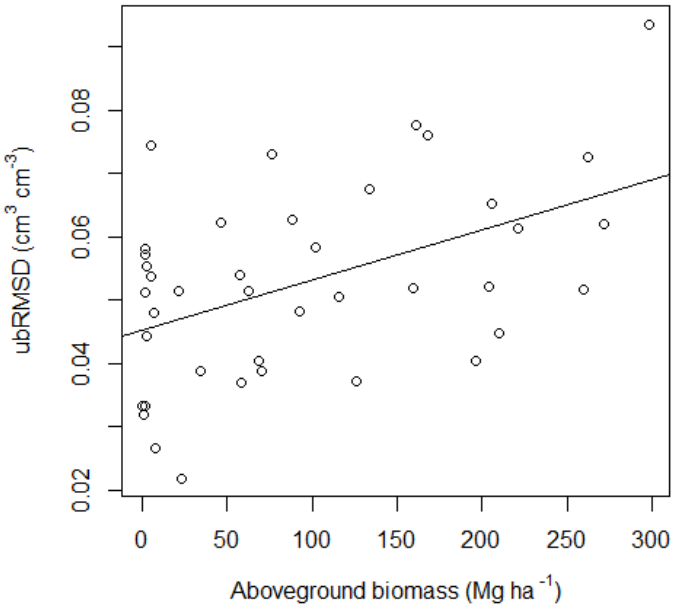
- Megapit and Initial Characterization Soil Archive
- Soil Distributed Periodic Archive
- Frozen Soil archive

Ayres E. 2019. Quantitative Guidelines for Establishing and Operating Soil Archives. SSSAJ 83, 973-981; https://doi.org/10.2136/sssaj2019.02.0050

Partnerships and Validation

- LTAR-NEON workshop (May-Jun 2021)
- National Coordinated Soil Moisture Monitoring Network
- NCAR incorporating NEON data into Community Land Model
- National Soil Moisture Workshop
- RUBISCO-AmeriFlux Spatial Scaling Working Group
- Critical Zone Collaborative Network Advisory Committee
- NASA SMAP validation and expansion to forest ecosystems

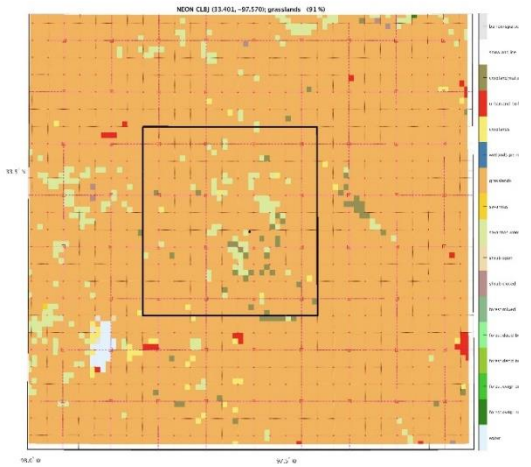
- NEON-SMAP unbiassed RMSD
  - Excluding forests: 0.047 ±0.014 $cm^3\ cm^{-3}$
    - SCAN: ~0.052 $cm^3\ cm^{-3}$†
    - USCRN: ~0.049 $cm^3\ cm^{-3}$†
  - Unbiased RMSD increased by ~0.01 $cm^3\ cm^{-3}$ for every 100 Mg ha^{-1} increase in aboveground biomass

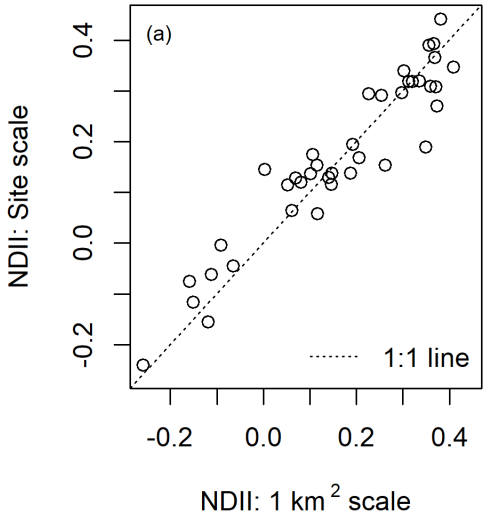


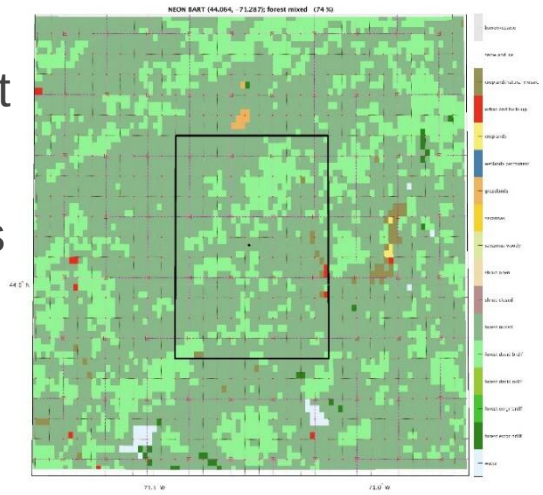
† Chen F. SMAP L2SMP_E T14000 (Dsc) Comparison at Sparse Networks, 3/31/2015–10/31/2016

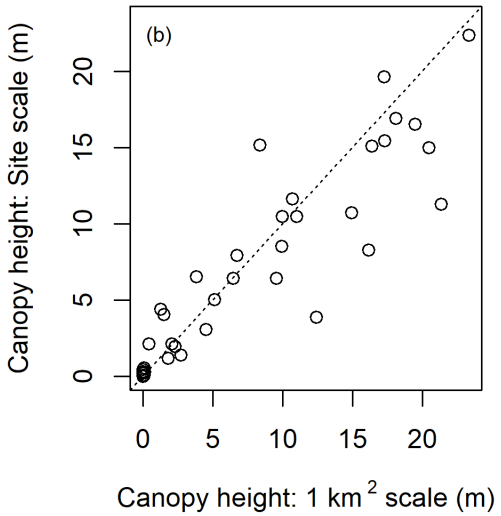
Potential enhancements for NEON soil moisture data

- Derived products
  - Soil moisture percentiles
  - Soil water potential
- Spatial context metadata
  - How representative are the measurement locations?
    - Satellite, model, and forecast validation
    - Land management decisions
- Join NEON Technical Working Groups (TWG)
  - Soil Sensor TWG









- Acknowledgements
  - Soil pits and site-specific calibrations
    - Josh Roberti, Hank Loescher, Jianwu Tang, Gregory Starr, David J. Durden, Derek E. Smith, Elizabeth de la Reguera, Kate Morkeski, Margot McKlveen, Heidi Benstead, Michael D. SanClements, Robert H. Lee, Maheteme Gebremedhin, and Rommel C. Zulueta, Melissa Slater, Courtney Meier, Cody Flagg, Jennifer Everhart, Julia Spencer, Holly Abercrombie, Oliver Smith, Alison Hogeboom, Mike Patterson, Rachel Krauss, Zhunqiao Liu, NEON site hosts and researchers, USDA–NRCS's soil scientists, especially Larry West, Jon Hempel, Doug Wysocki, Ellis Benham, Scarlett Bailey, Rick Ferguson, Steve Monteith
  - NEON-SMAP validation
    - Andreas Colliander, Mike Cosh, Melissa Genazzio, Mahesh Pun, Josh Roberti, Courtney Meier, Sam Simkin

neon
Operated by Battelle

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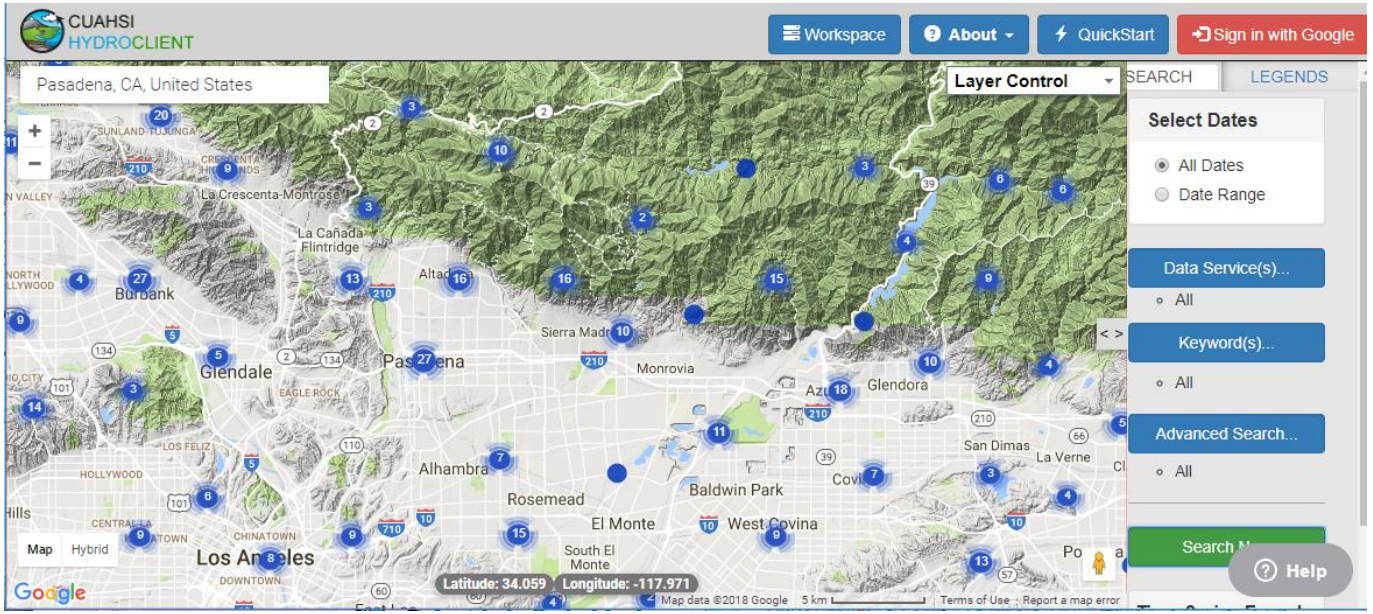
CUAHSI Water Data and Community Services



Jerad Bales

April 16, 2021

US GEWEX Soil Moisture Workshop

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CUAHSI Water Data Services

CUAHSI's Water Data Services support discovery, publication, storage, and re-use of water data and models, as well as tools for collaboration, thereby promoting reproducible discovery in the water sciences.

- **Recognized by r3data (registry of research data repositories) and selected journals.**
- **Signatory to FAIR agreement.**
- **Leadership in Internet of Water.**
- **Member of ESIP (Earth Science Information Partners) and affiliate status with GEO.**
- **Adhere to Schema.org standards.**
- **Applying for CoreTrustSeal recognition.**
- **Partnerships with other domain data repositories.**
- **Two technologies: HIS/Hydroclient and HydroShare, both developed through NSF research projects.**

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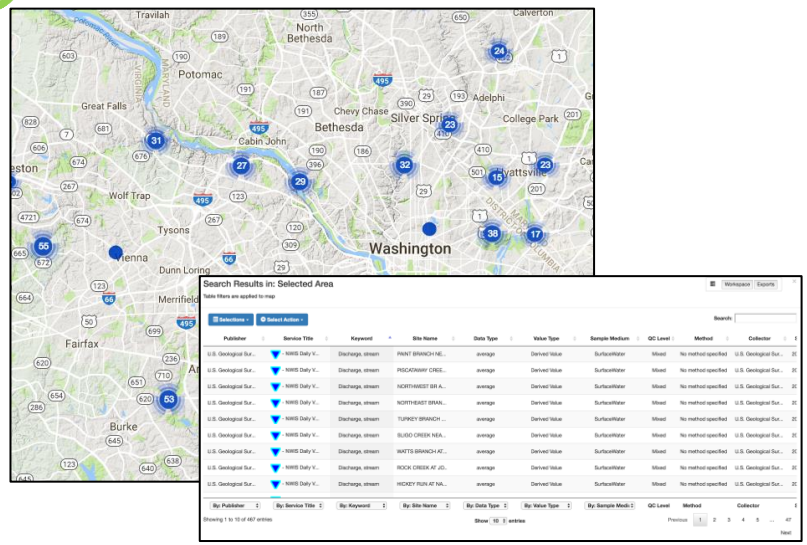
Discover & Access Data



Publish & Share Data

1 Create data

Collect your data using the same methods you use now. HydroShare supports a broad set of hydrologic data types.

2 Upload to HydroShare

Upload your data files to HydroShare through the web user interface. HydroShare will automatically extract as much metadata as it can from the files you upload.

3 Describe with metadata

Use HydroShare's simple metadata entry forms to finish describing your data so that your colleagues can find, access, and interpret it.

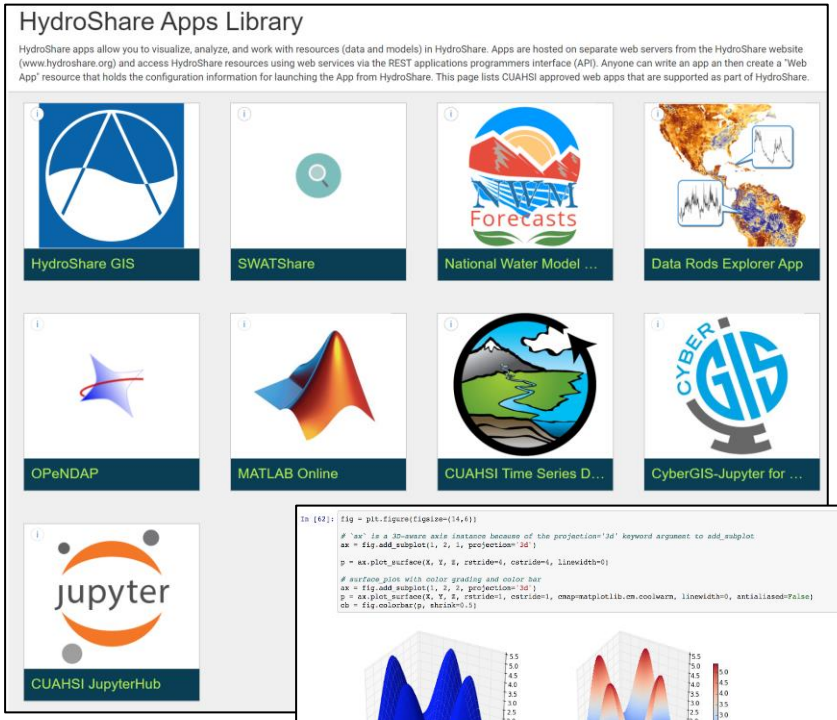
4 Share with colleagues

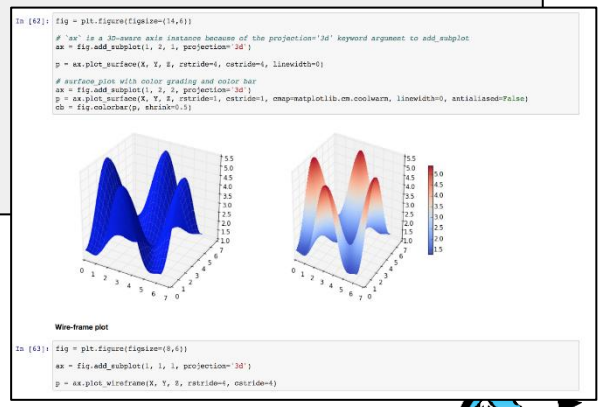
Choose who has access to the data and models you have uploaded to HydroShare. You can share with individual users or make your resources public for everyone to access.

5 Permanently Publish

Obtain a Digital Object Identifier (DOI) so your work can be easily cited. Reference related journal publications in your metadata.

Analyze Data with Computing Tools & Apps





HydroClient: Discover and Publish Time Series

- CUAHSI hosts a catalog of metadata from many sources.
- Users search the catalog via HydroClient map interface.
- Data are returned in a common format, regardless of source.
- Users can add their own metadata to the catalog using metadata templates.
- Users can upload (publish) their data to the service and obtain a DOI.
- Currently being modernized, with increased capabilities.

Catalog Statistics

Number of Data Sources	Properties Measured	Number of Time Series	Number of Locations	Number of Observations	Last Updated on
94	478	3,492,199	1,221,354	148,835,393,011	09/19/2020

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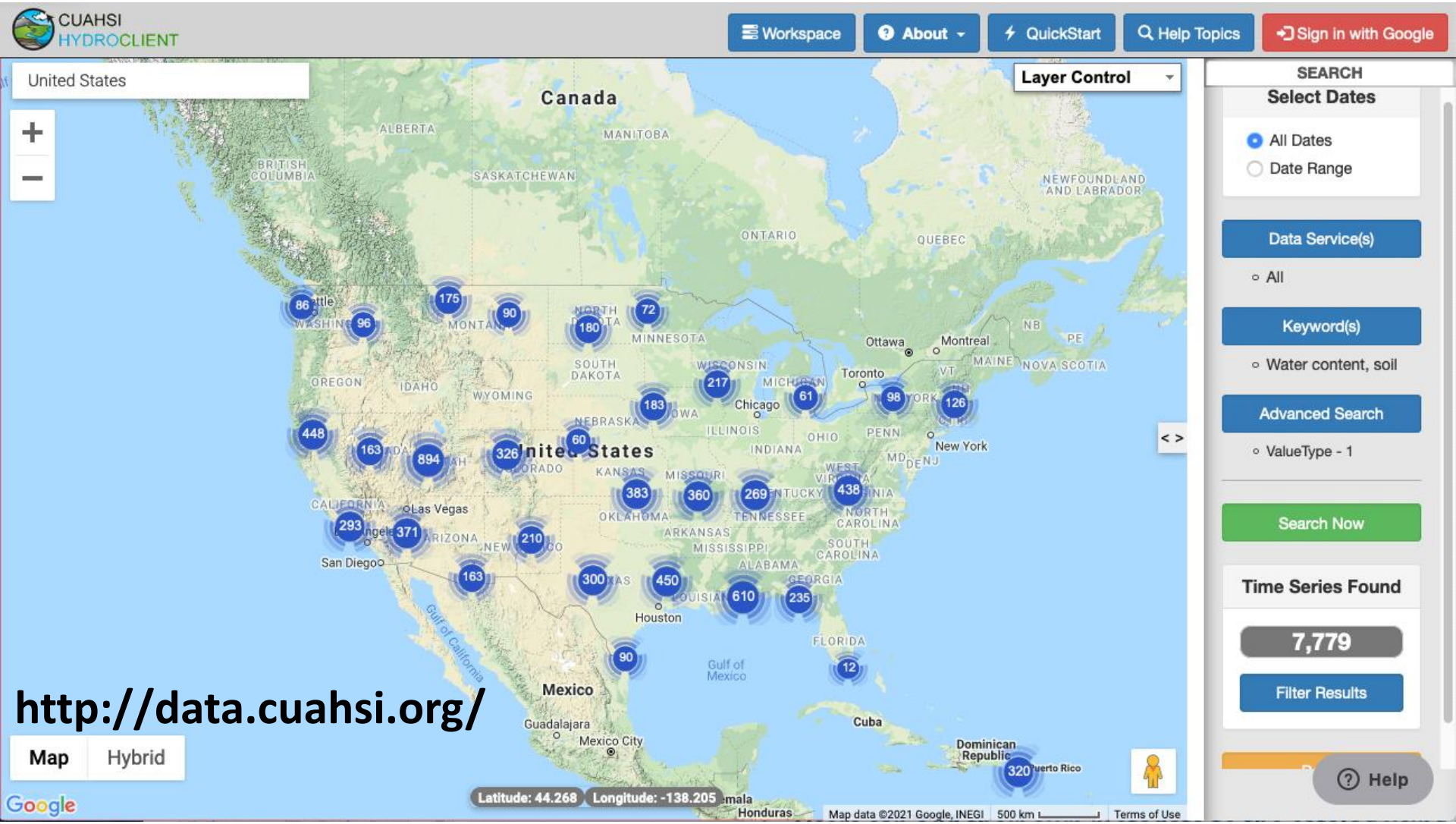
http://data.cuahsi.org/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Advanced Search
ValueType - 1
Search Now
Time Series Found
7,779
Filter Results
Help
Canada
United States
Mexico
Cuba
Chicago
New York
Toronto
Ottawa
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San Diego
Houston
Guadalajara
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Gulf of California
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Map
Hybrid
Latitude: 44.268
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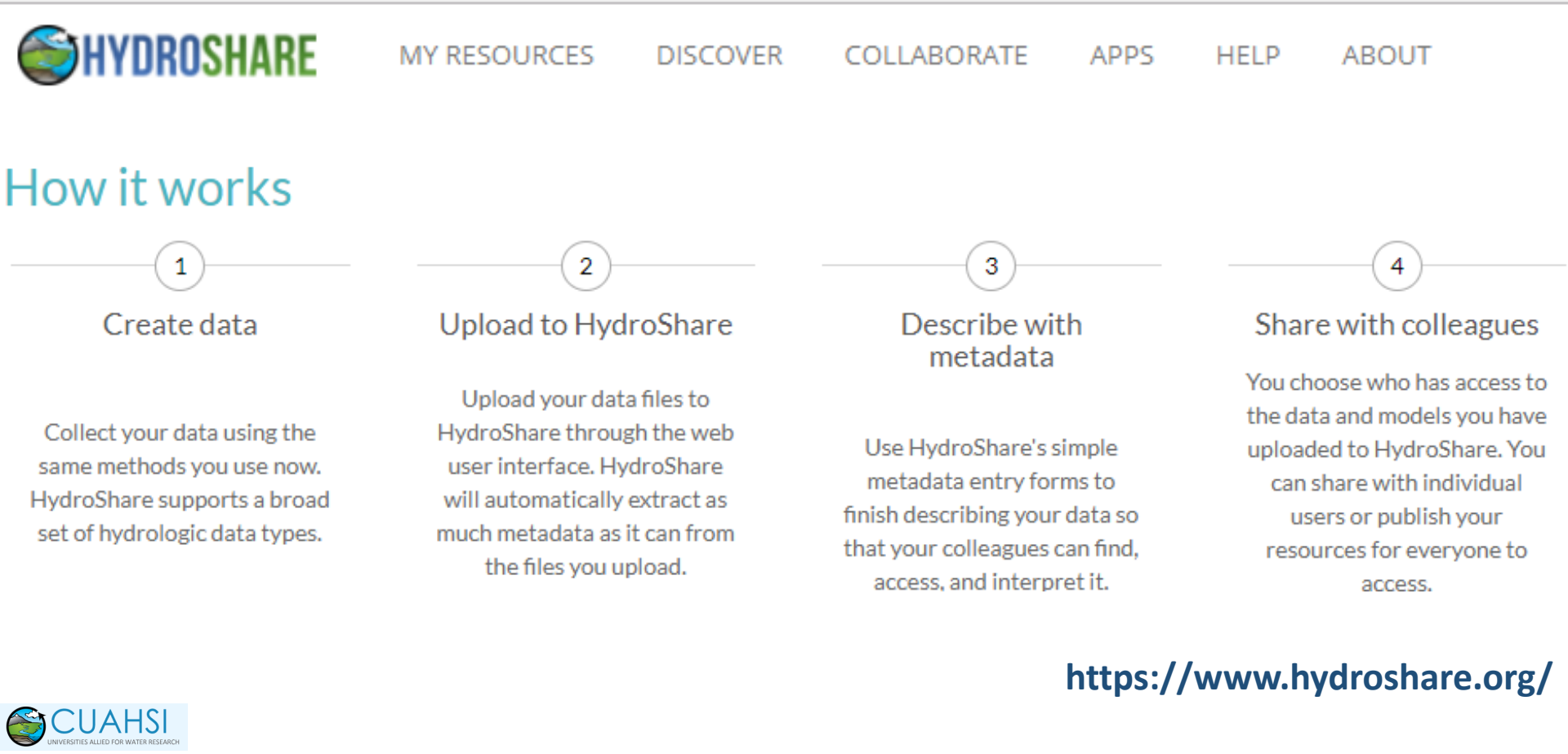
Find, Publish, and Operate on Water Data: HydroShare



https://www.hydroshare.org/

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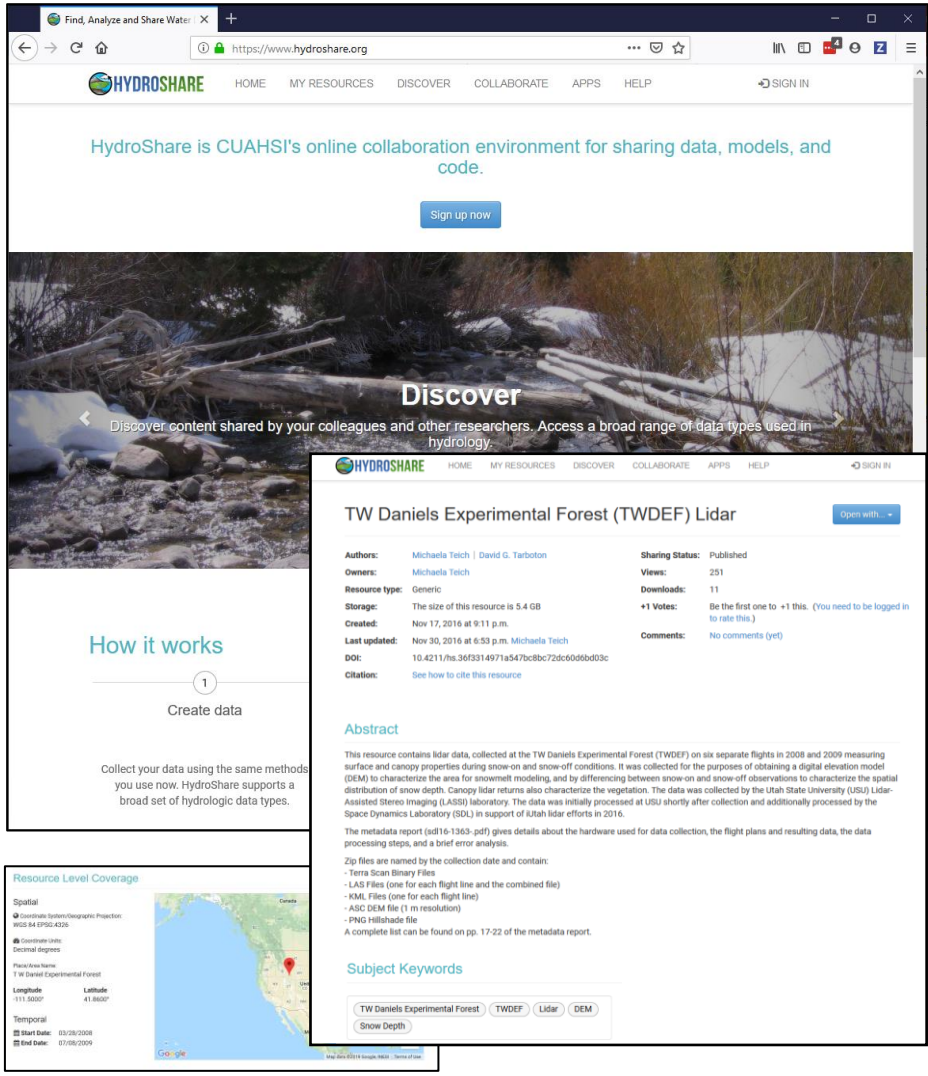
HydroShare: Data and Model Repository

- **Manage data, models, and workflows throughout research life cycle.**
- **Share data, models, and other research products.**
- **Permanent publication of data and models with citable digital object identifiers (DOIs).**
- **Fulfill Findable, Accessible, Interoperable, Reusable (FAIR) open data mandate.**



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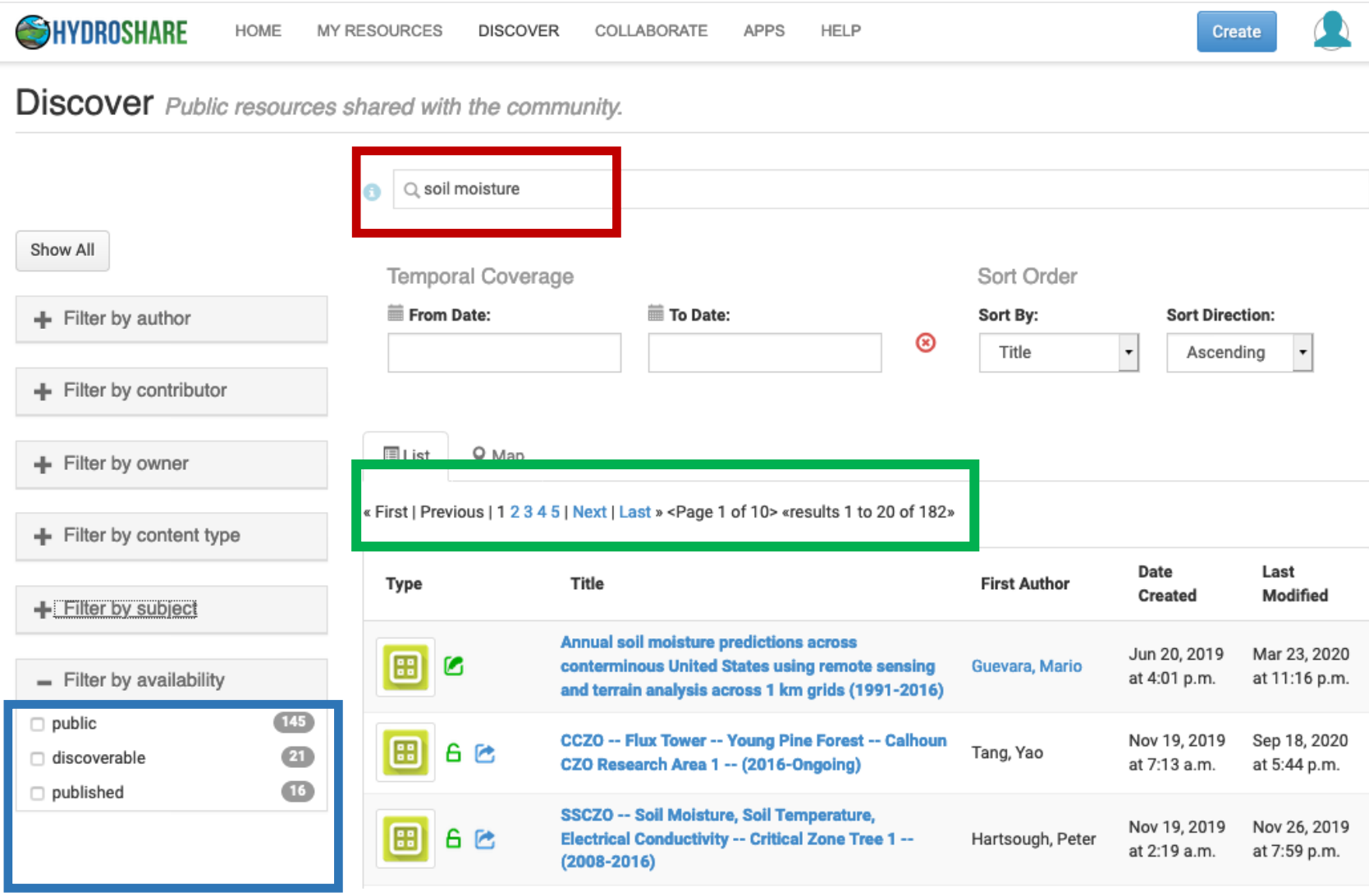
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APPS
HELP
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Discover
Public resources shared with the community.
soil moisture
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Temporal Coverage
From Date:
To Date:
Sort Order
Sort By:
Title
Sort Direction:
Ascending
Filter by author
Filter by contributor
Filter by owner
Filter by content type
Filter by subject
Filter by availability
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discoverable 21
published 16
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Map
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Type
Title
First Author
Date Created
Last Modified
Annual soil moisture predictions across conterminous United States using remote sensing and terrain analysis across 1 km grids (1991-2016)
Guevara, Mario
Jun 20, 2019 at 4:01 p.m.
Mar 23, 2020 at 11:16 p.m.
CCZO -- Flux Tower -- Young Pine Forest -- Calhoun CZO Research Area 1 -- (2016-Ongoing)
Tang, Yao
Nov 19, 2019 at 7:13 a.m.
Sep 18, 2020 at 5:44 p.m.
SSCZO -- Soil Moisture, Soil Temperature, Electrical Conductivity -- Critical Zone Tree 1 -- (2008-2016)
Hartsough, Peter
Nov 19, 2019 at 2:19 a.m.
Nov 26, 2019 at 7:59 p.m.

BCCZO -- Soil Temperature, Soil Moisture -- at various depths (GGU_NF_SP4_SLTmpSLMist_Array) -- Gordon Gulch: Upper -- (2009-2020)

Open with...

Authors: Suzanne Anderson | Dillon Ragar
Owners: CZO National | CZO Boulder
Resource type: Composite Resource
Storage: The size of this resource is 30.9 MB
Created: Nov 18, 2019 at 9:03 p.m.
Last updated: Aug 17, 2020 at 4:43 a.m. CZO Boulder
Citation: See how to cite this resource
Content types: Single File Content

Sharing Status: Public
Views: 335
Downloads: 22
+1 Votes: Be the first one to +1 this.
Comments: No comments (yet)

Abstract

Temperature and soil moisture sensors (campbell scientific 107 temperature sensors and CS616 soil moisture sensors) are installed at various depths below the ground surface to measure temperature and soil moisture.

QUERY PAGE HERE: https://bcczo.colorado.edu/query/ggu-nf-sp4-sltmpslmst.shtml

View logs for complete site history: https://www.dropbox.com/s/bxeuh43chrg5411/GGU_NF_SP4_Meta.docx?dl=0

Sensor group IDs and descriptions-

GGU_NF_SP4_CR10x

Sensors in the group

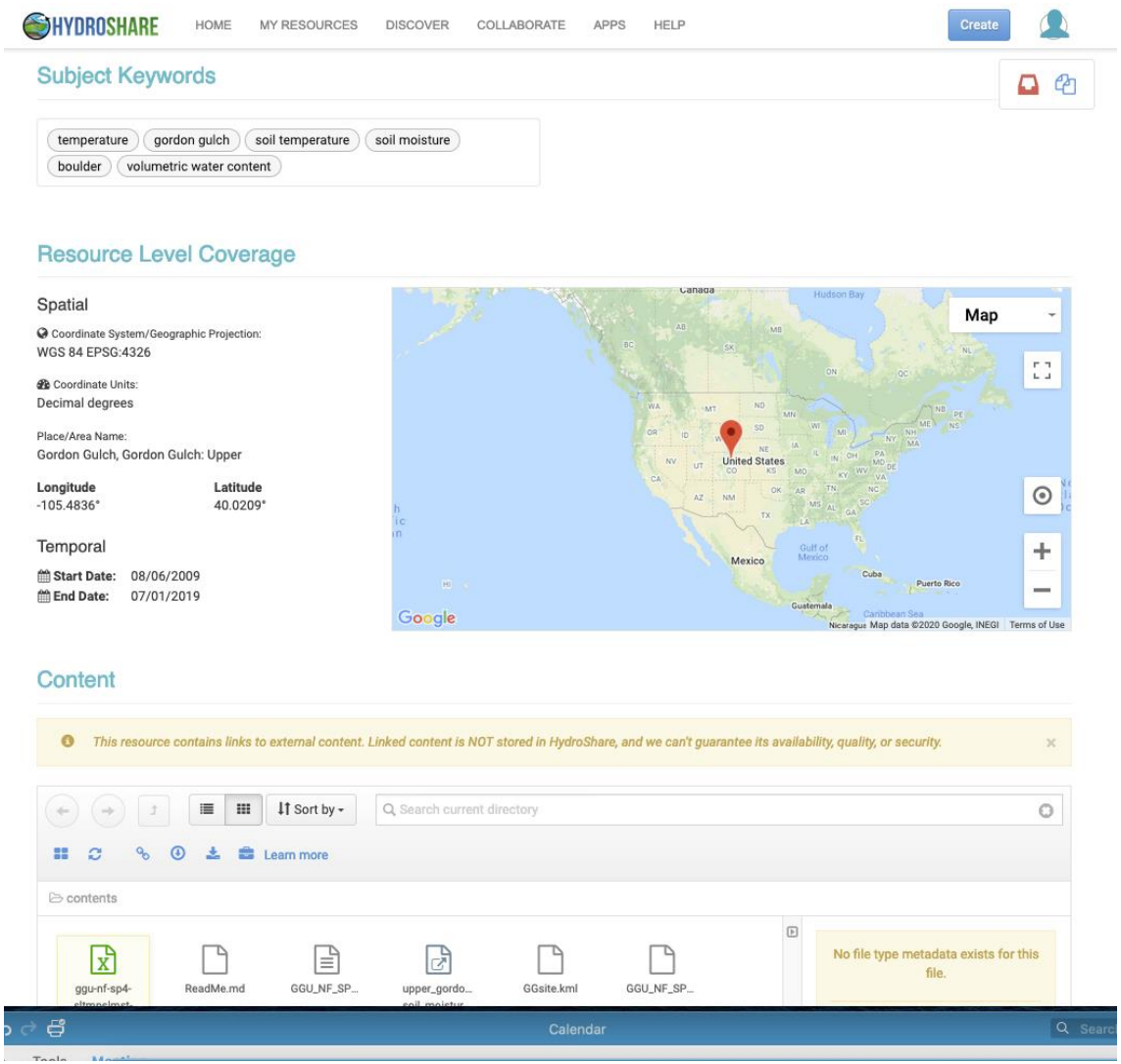
GGU_NF_SP4_M4_CS616_100, Soil Pit, Campbell Scientific CS616 soil moisture sensor

GGU_NF_SP4_M4_CS616_138, Campbell Scientific CS616 soil moisture sensor

GGU_NF_SP4_M4_CS616_5, Soil Pit, Campbell Scientific CS616 soil moisture sensor

GGU_NF_SP4_M4_CS616_50, Soil Pit, Campbell Scientific CS616 soil moisture sensor

GGU_NF_SP4_T107_100, Soil Pit, Campbell Scientific T-107 soil temperature sensor



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HYDROSHARE

Community Data Sets

Collaborate

GROUPS

COMMUNITIES

CZO National Community

Shared by

- CZO Boulder
- CZO Calhoun
- CZO Catalina-Jemez
- CZO Christina
- CZO Eel
- CZO Luquillo
- CZO National
- CZO Reynolds
- CZO Shale-Hills
- CZO Sierra

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https://www.hydroshare.org/

CUAHSI Community Services

CUAHSI develops and provides access to water-science community resources and training to build capacity, advance education, and extend existing research capacity. Examples include:

- **Grants: Learn how to use an instrument.**
- **Grant: develop or improve data tools or data access.**
- **Grant: Add a new field site to existing research.**
- **Grant: Engage the local community on water issues.**
- **Cyberseminar series.**
- **CUAHSI Virtual University**
- **Summer Institute: 7-week residential experience at the National Water Center.**
- **Community meetings.**
- **3- to 5-day on-site training courses.**
- **Multi-organizational workshops.**
- **Community announcements.**

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1. What is the rationale for the soil moisture measurements and/or products your group develops? Are you targeting research and/or operational application? Supporting data sharing, publication, and reproducible workflows.
2. Do you take or provide any co-located and/or related data in addition to soil moisture? For example, co-located atmospheric or flux measurements, ecological or hydrologic observations, etc. Site dependent: generally yes for CZO and NEON sites.
3. What enhancements (e.g., additional variable measurements, additional sites, increased resolution of products, etc.) do you think could provide additional scientific value and value to stakeholders? Single point and remotely-sensed products.
4. Do you have priorities, strategies or plans for any of these enhancements? Not applicable
5. With which other groups would collaboration add value to you or your stakeholders? One-off small data collectors (e.g., ag community, turf mgmt., etc.)
6. How can USGCRP / US GEWEX best engage you going forward?
7. What questions, ideas, or topics do you have for the meeting participants (e.g., other groups, U.S. agencies) that you would like to discuss or pursue together? Metadata standards, appropriate data models.

Thank you

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Brochdale, England, 2001
http://www.euwfd.com/html/groundwater.html

Development of Observation-based Global Multi-layer Soil Moisture Products for 1970 to 2016

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Rationale for Creating Merged Soil Moisture Products

Data source	Pros	Cons
In situ observations	More accurate than remote sensing or model products.	Represent only small spatial scale and too sparse.
Remote sensing observations	Global, relatively high-resolution coverage.	Have gaps, only represent the top soil.
Land surface models, reanalysis, and Earth system models	Gap-free, represent multiple soil layers.	Subject to modeling biases.

Merging multiple-source datasets would overcome the limitations of individual datasets, resulting in long-term, global, gap-free, multi-layer SM products for research purposes.

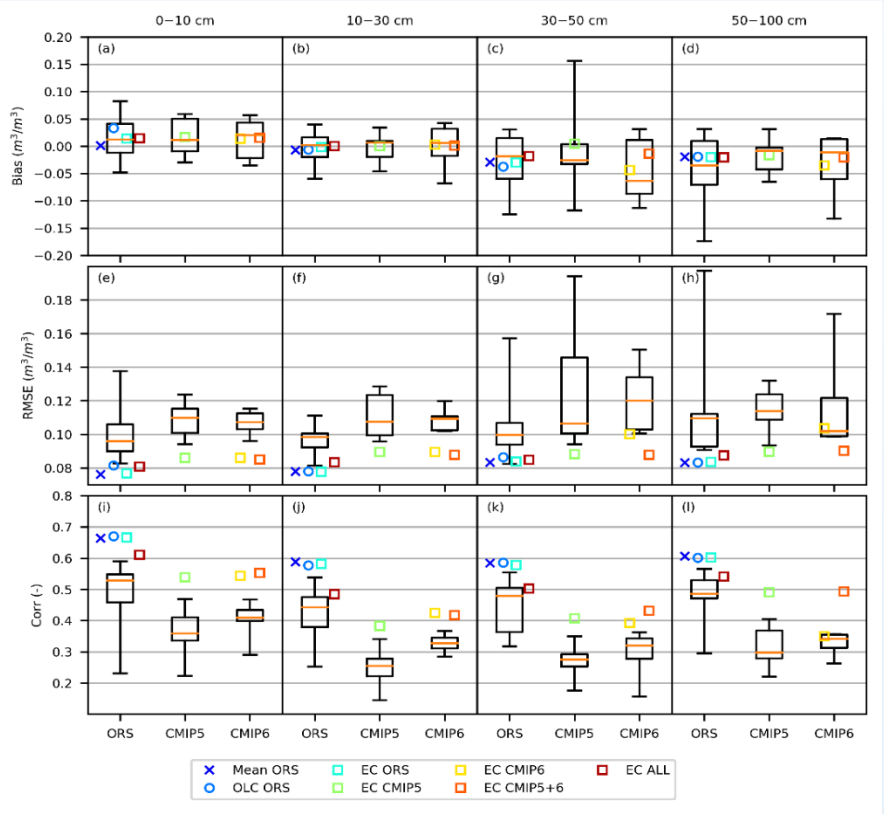
Merging Framework

Gridded data\Method	Unweighted averaging	Optimal Linear Combination (using in situ soil moisture observations)	Emergent Constraint (using gridded observed meteorological data)
Offline land surface model simulations, Reanalysis, and Satellite	Mean ORS	OLC ORS	EC ORS
Earth system models (CMIP5, CMIP6)	—	—	EC CMIP5, EC CMIP6, EC CMIP5+6
ORS and Earth system models	—	—	EC ALL

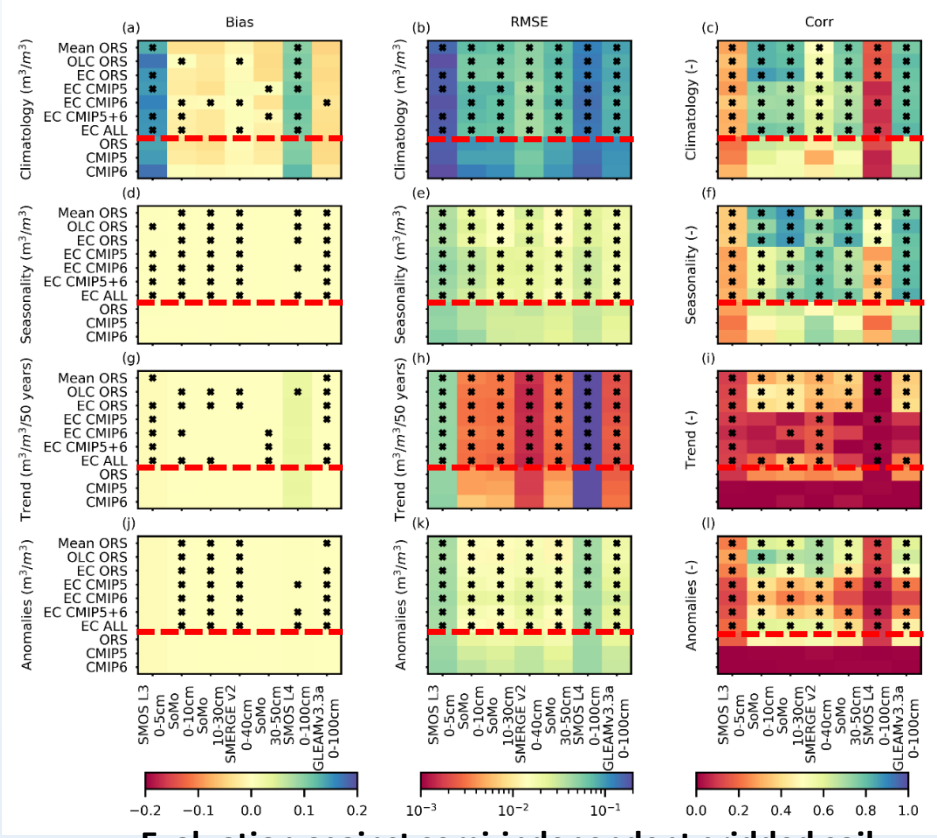
7 hybrid SM products based on 3 merging methods:

- ✓ *Coverage: global, 1970–2016;*
- ✓ *Spatial resolution: 0.5°;*
- ✓ *Temporal resolution: monthly;*
- ✓ *Vertical layers: 0-10cm, 10-30cm, 30-50cm, 50-100cm;*

Performance of the Merged SM Products

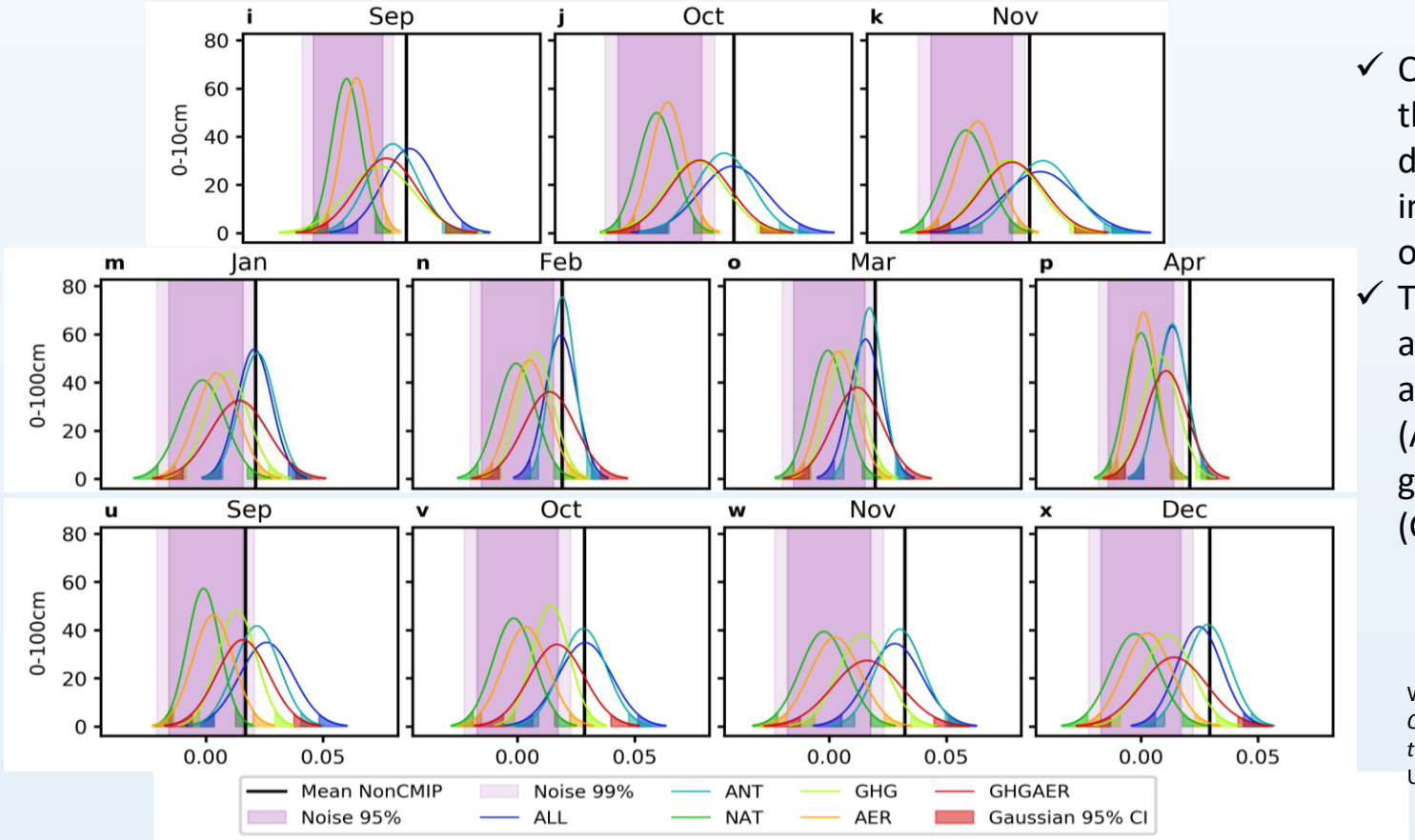


Evaluation against the validation set of *in situ* observations



Evaluation against semi-independent gridded soil moisture data (* means merged product have better performance)

Application I: Quantification of Significant Anthropogenic Signals in Different Soil Layers

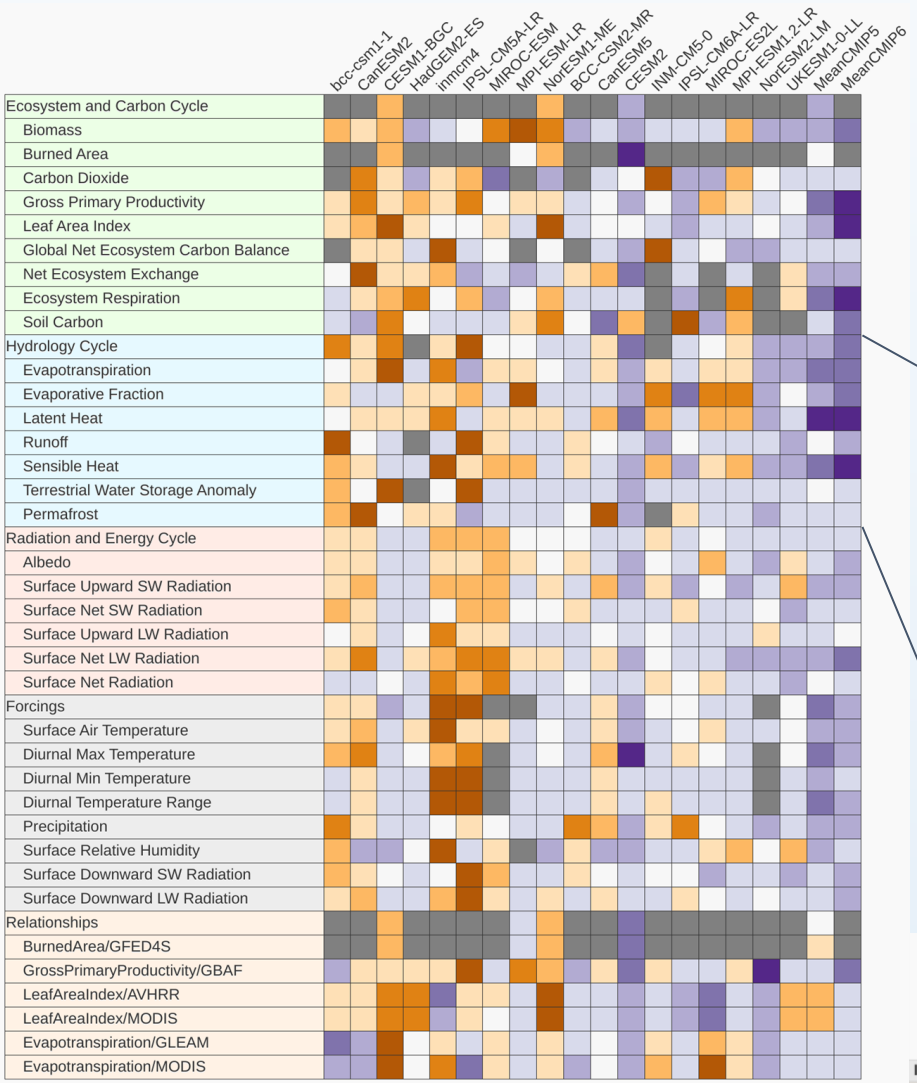


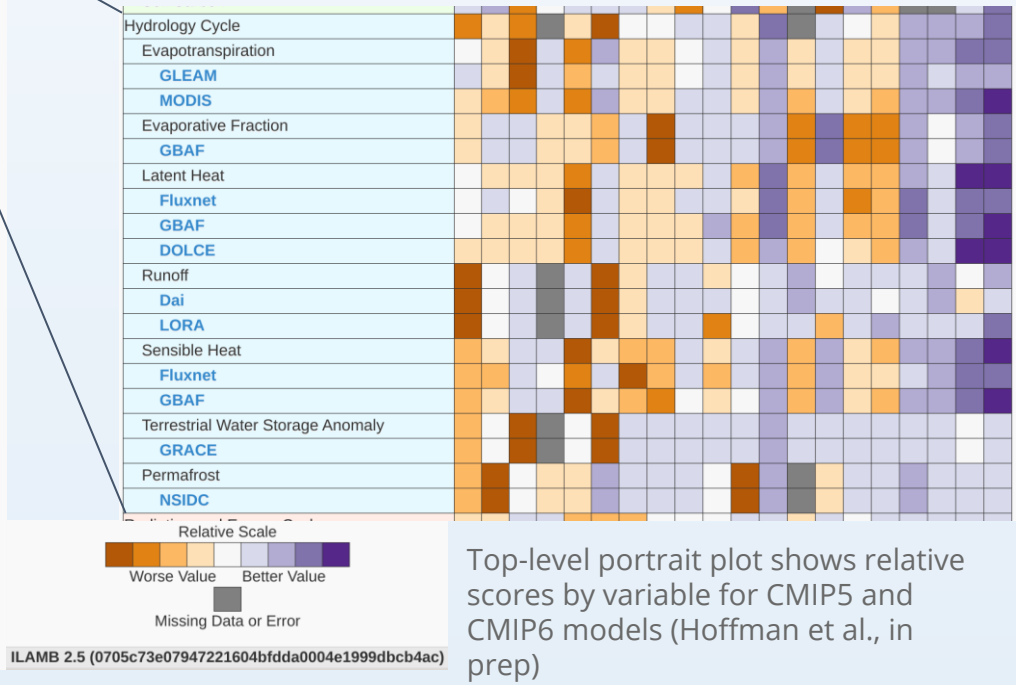
- ✓ Only some months of the year contain detectable signal, indicating the presence of seasonal variability;
- ✓ The signals are attributable to anthropogenic forcings (ALL/ANT), especially greenhouse gases (GHG);

Wang, Y., Mao, J., and coauthors.: *Quantification of Human Contribution to Soil Moisture-based Droughts*, Under review, 2021.

Application II: ILAMB Hydrology Benchmarking

- ILAMB evaluates model results by comparing with global-, regional-, and site-scale data
- The current set of variables and datasets (blue text) are shown below





Top-level portrait plot shows relative scores by variable for CMIP5 and CMIP6 models (Hoffman et al., in prep)

Next Steps

- **Further applications and development**
  - ✓ *Analyze the impacts of long-term soil moisture changes on C dynamics, "greening", and "browning";*
  - ✓ *Provide the initial and boundary conditions for atmospheric models (e.g., DOE E3SM, NOAA ESM4, NSF CESM);*
  - ✓ Assemble more in situ SM datasets (e.g., NCSMMN, NGEEs, AmeriFlux, NEON) and implement other advanced fusion algorithms (e.g., extended collocation, machine learning).
- **New soil moisture working group**
  - ✓ *Leverage existing AmeriFlux-RUBISCO and FSMWG (e.g., data synthesis and model-data integration);*
  - ✓ *Understand and benchmark the global SM dynamics using multi-source and multi-scale datasets;*
  - ✓ *Improve existing SM databases and benchmarking methods;*
  - ✓ *Find innovative ways to use benchmarking results to improve model parameterization, predictions, and projections.*

Thanks for Your Attention!
Questions and Comments?